U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1360

APPLE GROWING EAST OF THE MISSISSIPPI RIVER

THE fundamental principles of apple growing are discussed in this bulletin. Fruit can not be grown successfully by "rule-of-thumb" methods of procedure. The fruit grower who best understands the principles involved and applies them wisely is the one who usually succeeds, because he best meets the conditions of nature with which he contends.

From their inception many orchards are doomed to failure or to mediocrity of success only, because they are poorly located with respect to soil, local temperature conditions, or for some other reason which is inherent in the surroundings and which might easily have been avoided had the principles of good orcharding been observed in the beginning.

With the high costs that enter into the development and maintenance of apple orchards, any advantages of site and location and of favorable conditions with respect to regularity of crops, abundant yields, and perfection of development of the fruit may make a wide difference in the financial aspects of an orchard enterprise, as compared with one where adverse conditions occur. The aim of this bulletin is to help the grower in meeting some of the problems of apple-orchard planting and maintenance.

The extent of the apple industry is not easily comprehended. According to the Fourteenth Census, there were in 1920 in the United States 2,687,685 farms which reported apple trees of bearing age, as compared with 2,980,398 in 1910. The number of farms reporting trees not of bearing age was 1,034,114 in 1920, while in 1910 the number was 1,498,746. The value of the crop of 1919, as given by the Fourteenth Census, was $241,573,577; in 1909 the value was $83,231,492, according to the Thirteenth Census.

The estimated production of apples in the United States for the past several years is as follows:

Year.	Estimated production (barrels).	
	Commercial crop.	Total crop.
1919	26,159,000	47,362,000
1920	33,905,000	74,559,000
1921	21,557,000	33,001,000
1922	31,945,000	67,567,000
1923	34,303,000	65,590,000

The wide variation in the crop from year to year and the relation of the commercial crop to the the total production are always factors of importance in considering the apple industry.

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APPLE GROWING EAST OF THE MISSISSIPPI RIVER.

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THE POINT OF VIEW.

FRUIT GROWING is a business, and the commercial grower is a business man. The fruit grower's business is substantially that of manufacturing, and the orchard is his manufacturing establishment. The grower will do well to keep this viewpoint clearly in mind. A manufacturer of furniture or plows would not expect to have furniture or plows to sell unless he makes adequate provision for the necessary raw materials out of which such products are made. Too often, however, the apple grower looks for a profitable crop of fruit even though he has given but little attention to the essential details which render it possible for a crop to develop.

Moreover, fruit growing is a highly specialized type of agriculture. Yet frequently men entirely without knowledge of the requirements aspire to own and manage a commercial orchard enterprise, overlooking the fact that the first fundamental of success in any special line is a thorough working knowledge of the specialty.

RELATIVE IMPORTANCE AND DISTRIBUTION OF THE APPLE INDUSTRY.

The apple is the most important of all fruits grown in this country, both in money value and in the place which it fills in the diet; of the tree fruits it is grown more widely than any other, save perhaps the native plums represented by several species. Home orchards are found in every State in the Union except possibly Florida, and a few trees are found there. Orchards of commercial extent exist in more than 40 of the 48 States. Figures 1 and 2 show, respectively (on the basis of the Fourteenth Census, 1920), the distribution throughout the country of apple orchards of bearing and nonbearing age, the unit being 500 acres. Table 1 gives the number of bearing and nonbearing apple trees in 1910 and 1920.

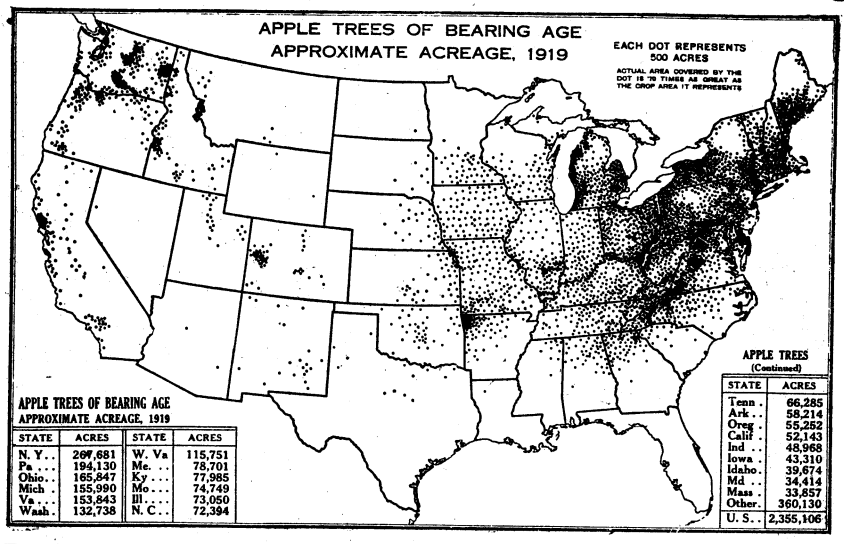
TABLE 1.—*Number of apple trees in the United States by geographic divisions and States according to the Thirteenth and Fourteenth Census reports.*

Division or State.	Number of apple trees.			
	Of bearing age.		Not of bearing age.	
	1920	1910	1920	1910
United States	115,309,165	151,322,840	36,195,085	65,791,848
Geographic Divisions:				
New England	6,351,577	8,219,152	2,123,730	2,094,512
Middle Atlantic	17,775,068	20,302,285	6,371,590	5,849,449
East North Central	22,449,054	34,134,909	7,678,220	10,610,319
West North Central	12,506,741	31,744,757	4,166,067	9,724,993
South Atlantic	20,777,465	20,673,712	8,051,972	10,064,819
East South Central	8,238,854	12,273,277	3,093,230	5,386,555
West South Central	6,007,845	11,838,069	1,586,538	7,224,590
Mountain	6,794,915	4,614,667	723,571	6,679,163
Pacific	14,407,646	7,522,012	2,400,167	8,157,445
New England:				
Maine	2,833,304	3,476,616	512,217	1,045,123
New Hampshire	721,130	1,240,885	227,933	207,289
Vermont	712,594	1,183,529	254,029	219,833
Massachusetts	1,218,870	1,367,379	791,771	355,858
Rhode Island	173,110	152,009	71,375	54,560
Connecticut	692,569	798,734	266,405	211,839
Middle Atlantic:				
New York	9,636,698	11,248,203	2,932,281	2,828,515
New Jersey	1,149,776	1,053,626	811,256	519,749
Pennsylvania	6,988,594	8,000,456	2,628,053	2,501,185
East North Central:				
Ohio	5,970,410	8,504,886	2,047,687	2,438,246
Indiana	3,427,816	5,764,821	929,160	1,961,974
Illinois	5,113,063	9,900,627	1,825,886	2,548,301
Michigan	5,615,905	7,534,343	2,050,229	2,253,072
Wisconsin	2,321,860	2,430,232	825,258	1,408,726
West North Central:				
Minnesota	1,596,264	1,380,396	637,187	1,571,816
Iowa	2,996,469	5,847,034	767,351	1,914,325
Missouri	5,162,859	14,359,673	1,585,823	3,624,833
North Dakota	26,157	15,941	19,694	70,023
South Dakota	255,637	274,862	136,082	490,547
Nebraska	961,313	2,937,178	401,788	967,133
Kansas	1,508,042	6,929,673	618,142	1,116,316
South Atlantic:				
Delaware	816,109	429,753	308,487	263,813
Maryland	1,651,936	1,288,482	766,264	660,685
District of Columbia	1,036	1,654	1,178	29
Virginia	7,385,277	7,004,548	2,857,007	3,435,591
West Virginia	5,554,731	4,570,948	1,735,126	2,772,025
North Carolina	3,474,821	4,910,171	1,394,588	1,835,337
South Carolina	377,557	581,767	181,101	269,044
Georgia	1,515,505	1,878,209	806,731	822,327
Florida	493	8,180	1,490	5,933
East South Central:				
Kentucky	3,742,936	5,538,267	1,427,408	2,106,297
Tennessee	3,181,659	4,838,922	1,032,490	2,117,246
Alabama	1,044,397	1,468,436	422,646	737,689
Mississippi	269,862	427,652	210,686	425,323
West South Central:				
Arkansas	4,074,870	7,650,103	877,376	3,940,039
Louisiana	47,037	93,304	44,175	96,544
Oklahoma	1,417,911	2,955,810	428,502	2,060,384
Texas	468,027	1,138,852	236,485	1,127,573
Mountain:				
Montana	1,059,198	696,753	69,328	1,308,066
Idaho	2,380,523	1,005,668	144,088	1,539,896
Wyoming	50,302	27,773	34,197	84,024
Colorado	1,777,737	1,688,425	183,315	1,972,914
New Mexico	687,799	542,528	167,097	914,254
Arizona	70,273	62,027	35,977	53,884
Utah	726,471	517,039	80,304	789,260
Nevada	42,612	74,454	9,265	16,868
Pacific:				
Washington	7,964,167	3,009,337	755,898	4,862,702
Oregon	3,315,093	2,029,913	500,322	2,240,636
California	3,128,386	2,482,762	1,143,947	1,054,107

In the geographical distribution of the apple, temperature is the chief limiting factor, though a moisture factor also exists in some regions. This is true especially in some parts of the Great Plains area where the rainfall is light and irrigation is impossible or impracticable. To a lesser extent the moisture factor prevails in some parts of the prairie sections which are characterized during the winter by low temperatures, a relatively dry atmosphere, and drying winds.

Temperature limits the extension of apple culture both northward and southward. Northward, beyond certain limits, the trees can not endure the winter extremes, while in some sections with less severe climates only the hardiest varieties can succeed.

The southern limits of apple culture are also determined mainly by temperature, the limiting factor being excessive and long-continued hot weather. Apple trees do not thrive in a region where the climate is characterized by long hot summers and by winters during



STATE	ACRES	STATE	ACRES
N. Y.	207,681	W. Va	115,751
Pa.	194,130	Me.	78,701
Ohio	165,847	Ky.	77,985
Mich.	155,990	Mo.	74,749
Va.	153,843	Ill.	73,050
Wash.	132,738	N. C.	72,394

STATE	ACRES
Tenn.	66,285
Ark.	58,214
Oreg.	55,252
Calif.	52,143
Ind.	48,968
Iowa	43,310
Idaho	39,674
Md.	34,414
Mass.	33,857
Other	360,130
U. S.	2,355,106

FIG. 1.—Outline map of the United States, showing the distribution of apple trees of bearing age. (Fourteenth Census, 1920.)

which the lowest temperatures reach but slightly below freezing, such temperatures occurring at infrequent intervals and for only brief periods. Thus, apple trees do not thrive well in the Gulf coast region and other parts of the country with comparable temperature conditions.

In order to thrive, apple trees require a definite period of rest brought about by low temperatures. If planted where the temperature and other conditions are favorable for continuous or nearly continuous growth, the tendency of the tree is to depart from its real nature and to attempt to become evergreen like an orange tree; for an apple to remain in active growth continuously without any dormant period is disastrous, the tree existing, if at all, only in a weak or dying condition.

While there are a few varieties that can be grown with some degree of success farther south than most sorts, this fact does not violate the general principles governing the southern limits of apple culture.

FACTORS TO BE CONSIDERED IN SELECTING AN ORCHARD LOCATION.

The location of an orchard is its geographical position in the State, county, township, or community where it occurs. It concerns transportation facilities, accessibility of markets, community interests, in a broad way the climate, and also the relation of natural features, like mountains, bodies of water, and the topography in general.

Inadequate shipping facilities present serious difficulties in marketing the fruit. Good rail or water transportation, in general, means easy access to markets. Distance naturally is a factor, but direct lines of communication often make possible quick deliveries to distant points, while the necessity of transfers from one road to another in reaching relatively near-by markets may mean disastrous delays.

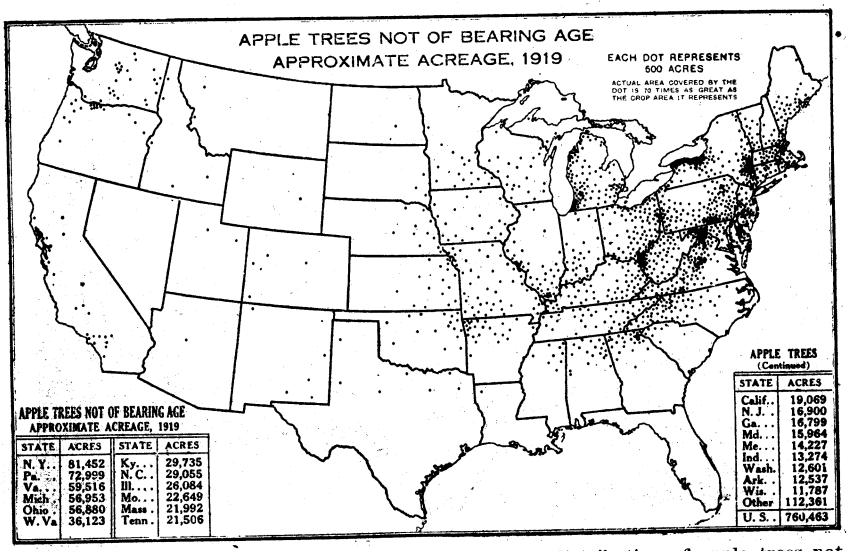


FIG. 2.—Outline map of the United States, showing the distribution of apple trees not of bearing age. (Fourteenth Census, 1920.)

An orchard in a community where there are large apple-growing interests, generally speaking, is located more favorably than one isolated with reference to other orchards. Large community interests attract more fruit buyers than do small ones; the product from the community standpoint becomes better known on the market than is likely when only small quantities of fruit are produced in the community; a larger number of more or less skilled laborers are likely to be developed locally; and advantageous cooperation among the growers in buying supplies and in handling the orchard business is possible. For these and other reasons one seeking an orchard location will do well usually to look where apples are already being produced in quantity.

Mountain ranges have an influence on the climate in modifying the force of winds and in determining frost lines. Locations near large bodies of water may be less subject to frost injury both in

spring and fall than inland localities. If a section is characterized by alternating hills and valleys, that is, if the topography is broken, better orchard sites can usually be found than in regions that are uniformly level.

The climate, especially temperature and moisture, has been referred to as the chief limiting factor in the distribution of the apple. Obviously, locations for orchards must be selected within the range of the climatic adaptability of the apple.

FACTORS TO BE CONSIDERED IN SELECTING AN ORCHARD SITE.

The site of an orchard has reference to the particular piece of land on which the trees are planted. Some of the factors of location are

FIG. 3.—An apple orchard in which all the trees are of the same variety. The trees in the distance are in full bloom, but the blossoming has been delayed in the hollow in the center because the cold air from the higher levels has settled there, thus retarding the rate of progress.

also factors of site. In selecting a site attention should be given to local climate, elevation, slope or exposure, soil, and sometimes to windbreaks. Other factors may also enter into the problem.

LOCAL CLIMATE.

With the location well selected, the local climate in relation to the site has to do largely with unseasonable frosts. Because relatively cold air is heavier than that which is warmer, it settles to the lower levels. Hence, "low ground" is frosty as compared with the higher slopes and ridges which may adjoin it. For this reason sites should be selected having good atmospheric drainage. One effect of atmospheric drainage may be seen by comparing Figures 3 and 4. Sites which are relatively high as compared with the surrounding areas afford good air drainage, other things being equal. For a similar

reason a slope is better than a level tract which represents the same elevation as the surrounding areas. On the other hand, slopes which are so steep as to make the care of the orchard difficult ought to be avoided unless there are compensations of adequate value to justify their use. The particular point of the compass toward which the slope inclines is of secondary importance except where it is very steep. Under the latter conditions the activities of the trees might be hastened on a southern and retarded on a northern exposure. These results would be favorable or not, depending on their correlation with other factors. Also, a steep slope away from the direction of strong prevailing winds may afford some protection.

Again, a site in close proximity to a large body of water is usually comparatively frost free. The influence of such bodies of water is to retard vegetation in the spring until the danger of frost is past and to delay the occurrence of frosts in the autumn.

FIG. 4.—The same orchard shown in Figure 3, photographed one week later. The trees in the distance are now nearly past bloom, while those in the hollow are almost in full bloom. Practically two different climates with regard to temperature conditions have prevailed in this orchard.

SOIL.

The soil factor is fundamentally important in relation to orchard sites, but it does not have the narrow limits sometimes supposed to exist. There are types of soil in certain localities which are recognized as giving especially good results with apples, and, in a broad way, soils having certain characteristics, especially with reference to their moisture-holding capacity, are sometimes recognized as being desirable for particular varieties.[1] These are finer distinctions, however, than the average grower is likely to make in selecting orchard sites.

[1] For a further discussion of the adaptability of soils to certain varieties, see Wilder, Henry J., Soils of Massachusetts and Connecticut, with especial reference to apples and peaches. U. S. Dept. Agr. Bul. 140, 73 p., 21 pl. 1915. Price 25 cents, from the Superintendent of Documents, Government Printing Office, Washington, D. C.

To be suitable for apples a soil must be well drained, be retentive of moisture to a favorable degree, and possess a good degree of fertility, either naturally or as a result of the management it has received. The subsoil must be deep and reasonably friable. These soil qualities need to be emphasized. Apple trees can not thrive where the soil holds free water, that is, water that can be seen as such, for any considerable period of time in the spring or after heavy rains. On the other hand, a "leachy" soil which suffers quickly in time of drought is to be avoided. That a soil must be fertile is self-evident; otherwise the trees can not make a good growth. Frequently, however, the importance of this factor is not realized.

SUBSOIL.

The importance of the subsoil is often overlooked. It is of greater concern, even, than the surface soil. It holds a large proportion of the root system of the trees and compared with the surface soil is less subject to improvement by methods of management.

The subsoil not only holds most of the roots but it is the reservoir from which the roots must draw the moisture required by the trees. If it is too hard and impervious, as in the case of the very heavy clays, moisture works through it slowly and it is likely to be poorly drained.

The other extreme, a coarse gravelly subsoil through which the water passes very quickly to depths beyond which the roots extend, is no less objectionable. Such soils are too subject to drought except in seasons of very favorable rainfall. Furthermore, subsoils must have sufficient depth. Shallow subsoils lack storage capacity for moisture and plant food. Many apple orchards in the past have been planted on sites where the subsoil was underlain with solid rock 2 or 3 feet below the surface (fig. 5), only to fail when the trees attained full bearing age, or even before, if severe drought has prevailed. Such soils are likely to be poorly drained in seasons of excessive rainfall.

For these reasons, soils which in general are described as loams, including the different types between sandy loams and clay loams, underlain by a deep friable subsoil, represent desirable types for apples. On the other hand, excellent orchards often occur on light sandy as well as on heavy clays where the other conditions are favorable.

ROADS.

The selecting of a site with reference to roads has to do with transportation problems—the hauling of supplies to the orchard and of the fruit from the orchard to the shipping station or to market. The coming of the autotruck, making practicable the growing of fruit a considerable distance from the shipping station or local market, has served to emphasize the relation of good roads to fruit growing.

WINDBREAKS.

Windbreaks or shelter belts, in relation to orchard sites, have been much discussed at times. In regions where there is much wind which

may cause loss by injuring the blossoms or blowing off the fruit or which may be so continuous as to cause the trees to become misshapen and one sided, a "belt" of strong-growing trees—evergreens, maples, poplars, or sometimes a combination of such trees as are best adapted to the conditions—is advantageous in breaking the wind. Besides trees planted especially with such protection in view, a windbreak may consist of natural forest growth, or of hills, ridges, or other natural features which modify the force of the wind. The need of this provision, however, depends on local conditions.

FIG. 5.—A thin stratum of soil underlain with a stratum of rock. Orchards on such sites may thrive for a time, but ultimate failure is practically certain, as many apple growers have learned to their sorrow.

PROPAGATION OF APPLE TREES.

The propagation of apple trees is the business of the nurseryman rather than of the fruit grower, and as a rule the latter will get better trees and probably at smaller cost in the end if he buys them than if he tries to propagate them himself. However, the fruit grower ought to know the general features of practice in the propagation and growing of trees in the nursery, as such knowledge

will make him a better judge of the trees he handles when he plants his orchard.

The foundation of the tree is a small seedling on which the variety to be propagated is budded or grafted. What are known as "French crab" seedlings are largely used as stocks. These are imported from France or are grown in this country from seeds that come from France. American-grown seeds are also used to a limited extent in growing stocks.

If the nurseryman is to propagate by grafting, he uses seedling stocks or roots that have made one season's growth from the seed. The roots are cut into pieces about 3 inches long, and the scions of the desired sort are grafted on them by the whip-graft (sometimes called tongue-graft) method. This is done during the winter, and the grafts are stored in sand in a root cellar or otherwise until they can be lined out in the nursery row in the spring.

This practice is termed "piece-root grafting." Sometimes the entire root system of the seedling stock is used for a single scion. This is called whole-root grafting. In this case the graft union is made at or near the crown of the seedling stock.

If propagation is by budding, seedling stocks are lined out in the nursery in the spring, grown there until July or August, and then budded at a point about 2 inches above the surface of the ground. The shield-bud method is used. The buds that are inserted on the stocks during the summer remain dormant until the following spring.

Other features closely related to nursery practices are briefly presented in the discussions that follow.

FIG. 6.—A well-developed case of hairy-root. Trees so affected should not be planted.

SELECTING APPLE TREES FOR PLANTING.

The matter of first importance in selecting nursery stock is to get good trees. Quality, however, is not dependent solely on size. A tree that is unduly small is likely to be stunted and weak. Such trees are usually expensive even as a gift. An especially large tree is heavy to handle, its weight adds unnecessarily to the cost of transportation, and it has other disadvantages. Therefore, a thrifty well-grown tree, typical of the variety, free from all insects and diseases, and of medium size for its age is usually to be preferred.

It is difficult to tell just what such a tree looks like. There is much difference in the way in which different varieties grow in the nursery. Some naturally make a strong, straight, vigorous growth; others are characteristically weak, crooked, or sprawling in habit of growth.

Particular attention should be given to the root system. To be well grown in this respect a tree should have several main roots,

well distributed and well branched into smaller, finer roots. On the other hand, a large mass or tuft of hairlike roots growing from a common point suggests hairy-root (fig. 6). Another form of hairy-root is shown in Figure 7. Wartlike bunches or knobs on the roots, especially on the main stem just below the surface of the ground or on the larger roots near the points where they branch from the main root, usually indicate crown-gall (fig. 8). In either case, the trees should be destroyed. If planted they might grow well for a time and perhaps come into bearing even sooner than others not so affected, but the probability of their making other than a weak, stunted growth and being short-lived is too great to justify planting them. Enlargements on the roots may be caused by woolly aphis (fig. 9), but the differences between them and crown-gall are usually quite characteristic. Trees that have been badly damaged by woolly aphis should be discarded, and trees still infested should not be planted without first treating them to kill the insects.

FIG. 7.—Another form of hairy-root, less advanced than that shown in Figure 6.

FIG. 8.—Hard form of crown-gall at the lower end of the scion, in a root-grafted apple tree.

AGE OF APPLE TREES FOR PLANTING.

Apple trees which have made one season's growth in the nursery are termed 1-year-old trees without regard to the fact that the roots may be considerably more or the tops considerably less than 12 months old. In the same way a 2-year-old tree is one the top of which has made two seasons' growth in the nursery.

Two-year-old apple trees are more generally planted than trees of any other age, but there is an increasing demand among growers of experience for 1-year-old trees. Trees older than 2 years are rarely planted in commercial orchards.

The advantages of 1-year-old trees over older ones, without regard to relative importance, are that they usually cost less, are lighter to handle and shipping costs are less, withstand transplanting better, and fewer trees fail to grow when planted in the orchard. They consist of a single unbranched stem, and the grower therefore can form the head at any height and in any way that he desires, and they come into bearing practically as soon as 2-year-old trees.

Perhaps the most tangible advantage of 2-year-old over 1-year-old trees has to do with the grower rather than with the tree itself. The 2-year-old tree is more or less heavily branched; therefore the foundation of the future top is formed when received by the grower. The grower selects the branches which are needed for the permanent framework or scaffold of the top and removes the others. The grower who is without experience will probably do better with a tree that is well branched when he receives it than he would in developing a top on a 1-year-old tree which comes to him simply as a straight, unbranched stem. To the grower who knows how to develop the top, a tree

FIG. 9.—Characteristic enlargements on the roots of apple trees caused by the wooly aphis. Compare with Figure 8, which shows enlargements due to crown-gall.

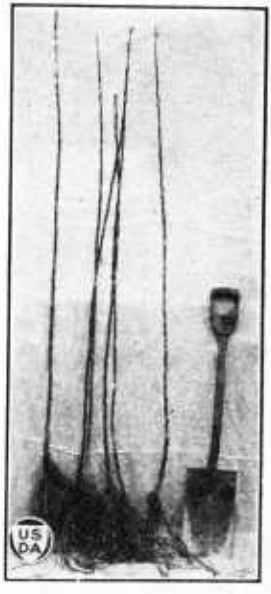


FIG. 10.—Good-sized, well-grown 1-year-old Stayman Winesap apple trees. Compare with the 2-year-old trees shown in Figure 11.

on which the head is already formed when received may be a distinct disadvantage. The unbranched 1-year-old tree can be developed in accordance with the ideals of the grower. The branched top of an older tree restricts the grower somewhat in this particular. Figures 10 and 11 show, respectively, well-grown 1-year-old and 2-year-old Stayman Winesap apple trees as received from the nursery.

WHERE TO GET THE TREES AND HOW.

In buying nursery stock the essential thing is to get good, well-grown trees. The production of good trees depends upon favorable

conditions in the nursery and the use of proper methods. These factors are not peculiar to any particular section.

The inherent characteristics of a variety do not change when the trees are grown in different sections of the country. If the variety is hardy, it will continue to be so; if it is susceptible to some disease, it is not made less so by growing the tree during its nursery period in some particular region.

For economy in transportation trees should be bought from a source as near the place where they are to be planted as practicable. Moreover, trees which are a long time on the road are likely to suffer injury unless they are carefully packed, especially if they pass through severe extremes of temperature while in transit. On the other hand, advantages in price, the desire to obtain trees of a particular variety, or some other reason may make it advisable to purchase elsewhere than at the nearest nursery.

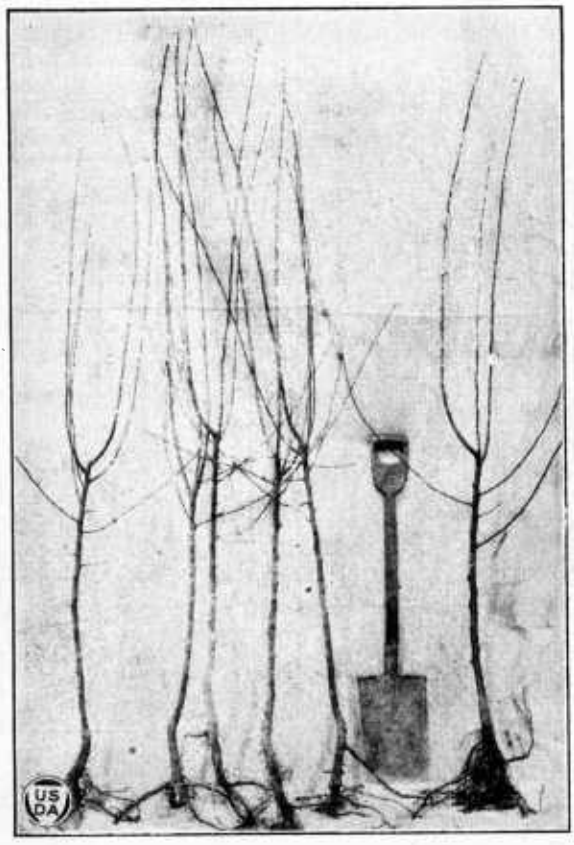


FIG. 11.—Well-grown 2-year-old Stayman Winesap apple trees. Note the branching as compared with the unbranched stems of the 1-year-old trees shown in Figure 10.

Since it is of the utmost importance that trees be dormant when planted, it is wise to purchase them from points north rather than south of the place where they are to be used when ordered for spring delivery. This is for the obvious reason that the growing season advances from the south northward, and nursery stock at southern points, otherwise desirable in every way, is likely to start growth in the spring before favorable conditions for planting have arrived farther north, the terms "north" and "south" being here used in a relative, not regional, sense.

Apple trees are graded according to height and caliper (the diameter of the trunk at a certain point above the ground). The grade designations commonly used for 2-year trees are: Large, height 6 to 7 feet, caliper three-fourths inch and up. Medium, height 5 to 6

feet, caliper five-eighths to three-fourths inch. Small, height 4 to 5 feet, caliper three-eighths to one-half inch. Or these grades may be represented by XXX, XX, and X, respectively.

The grades of 1-year-old trees are usually based on height only, as 2 to 3 feet, 3 to 4 feet, 4 to 5 feet. The price usually varies with the size of the trees; hence, in ordering, the purchaser should state clearly the grade desired.

HANDLING THE TREES WHEN RECEIVED FROM THE NURSERY.

When received from the nursery the trees should be unpacked immediately. Every possible precaution should be taken to prevent the roots from becoming dry. Unless the trees can be planted

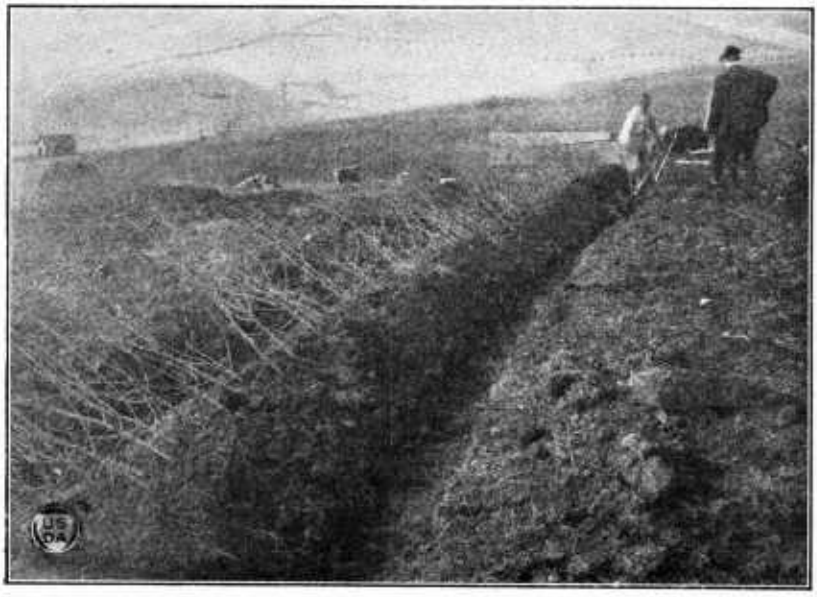


FIG. 12.—Heeling in apple trees to prevent the roots from becoming dry and the trees otherwise injured pending planting. The next row of trees is put in the trench made in covering the one already in place.

at once, they should be heeled in at a well-drained place where the soil is mellow and deep. A trench sufficiently wide and deep to receive the roots is made; then the trees are placed in it in the manner shown in Figure 12. In covering, the soil should be worked among the roots of the trees sufficiently to fill all the spaces among them. If a large number of trees is to be heeled in at the same place, it will be convenient to place them in closely adjacent rows. When this is done, the trees in one row may be covered with the soil which is removed in opening the next trench.

Trees that are tied in bundles when received must be separated before being heeled in. If this is not done it is difficult to work the soil among the roots sufficiently to prevent them from drying to a serious extent.

DETAILS OF PLANTING APPLE TREES.

WHEN TO PLANT.

There is a wide range in the time when apple trees may be planted successfully. Aside from convenience, the climate is the most important determining factor. In general, planting as early in the spring as the soil can be properly prepared is to be advised in the North. In middle latitudes and in the South planting late in the autumn shortly before the ground begins to freeze is usually safe. In fact, where the soil is well supplied with moisture, fall planting in the milder parts of the country is likely to prove preferable to spring planting, provided the winter following is not extremely cold.

Aside from these general principles, considerable adaptation to personal choice and convenience is possible. In the milder sections of the country planting is practicable throughout a large part of the winter.

Where planting in the fall is practiced the tendency often is to do it too early, thus frequently necessitating the stripping of the leaves from the trees in the nursery before they drop naturally in order to hasten maturity. The latter practice is probably not to be recommended.

PREPARATION OF THE SOIL FOR PLANTING.

As an ideal the preparation of the soil for planting apple trees should not be less thorough than for the planting of corn or potatoes. Neglect in the preparation will usually prove costly in the labor required later on or in the growth of the trees. In general, deep plowing and subsequent cultivation in order to pulverize the soil will constitute the final steps for putting it in suitable condition for planting. But not infrequently much preliminary work is needful.

If the soil is not already well drained, thorough drainage before planting is a necessity.

While it is essential that the soil be at least moderately fertile in order that the trees may grow well, its physical condition is of even greater importance than abundance of plant food. A soil in poor physical condition is usually unproductive regardless of how much plant food it may contain.

For these reasons, the preparation of the soil for an apple orchard may need to begin some time in advance of the planting with heavy applications of manure, not only to enrich it but as a means of supplying humus, or green-manure crops may be grown on the land in anticipation of the future planting of trees and such crops plowed under. In regions to which red clover or alfalfa is adapted, the plowing under of these crops is an excellent preliminary step. However, this should be done a sufficient length of time in advance of the planting to permit the roots and sod to become well decayed; otherwise they will interfere with the planting. For the same reason, sod land intended for orchard purposes should be plowed well in advance of the actual planting of the trees.

While this thoroughgoing preparation of the soil is the ideal, and it will doubtless pay as a rule to attain it to the largest extent prac-

ticable, various compromises may be adopted under some conditions without seriously jeopardizing the future of the orchard. An experienced grower who understands soil-improvement and soil-management methods can take liberties not otherwise generally advisable. For instance, if the site is favorable in other respects but the soil is in poor physical condition, it may be feasible to prepare strips several feet wide in a manner approaching the above stated ideal along where the rows of trees are to be planted and then, following the planting, to continue the soil improvement, each year extending the width of the strips along the tree rows. However, the roots of thrifty trees spread out far beyond the branches much more rapidly than is commonly realized. Improvement of the entire area between the rows of trees should not be much delayed; otherwise the trees are likely to suffer.

FIG. 13.—A terraced orchard. Terraces are constructed in some cases where washing of the soil is difficult to prevent by other means. The terraces should be started before the trees are planted. In this case the tree rows follow the contour of the land.

Where this plan of delaying the complete preparation of the soil until after the trees are planted is adopted, the grower should devote the entire area between the trees to soil improvement until that end has been accomplished. He should grow green-manure and cover crops between the trees and adopt such other soil-improvement methods as may be practicable. The growing of interplanted or secondary crops to be removed should not be permitted until the condition of the soil fully justifies it.

Under some conditions where it is difficult to prevent the soil from washing, terraces are used, as shown in Figure 13. The terraces should be started before the trees are planted.[2]

[2] Ramser, C. E. Terracing farm lands. U. S. Dept. Agr., Farmers' Bul. 997, 40 p., 38 fig. 1918.

DISTANCE FOR PLANTING.

Perhaps planting the trees too close together is more nearly a universal defect in apple orchards than anything else that can be mentioned. This close spacing causes disaster in later years, when the trees begin to crowd. Possibly the most serious aspect of this is the fact, hidden in the soil, that the roots begin to crowd long before the branches do. Where the tops crowd, the trees can not be sprayed well. The branches are reaching upward for light, and the bearing surface is in the extreme top, where it is difficult to spray thoroughly or to reach the fruit at picking time.

In deciding on the distance between trees the variety, character of the soil, and region should be taken into account. Different varieties vary in vigor and strength of growth and in expansion of limbs. A

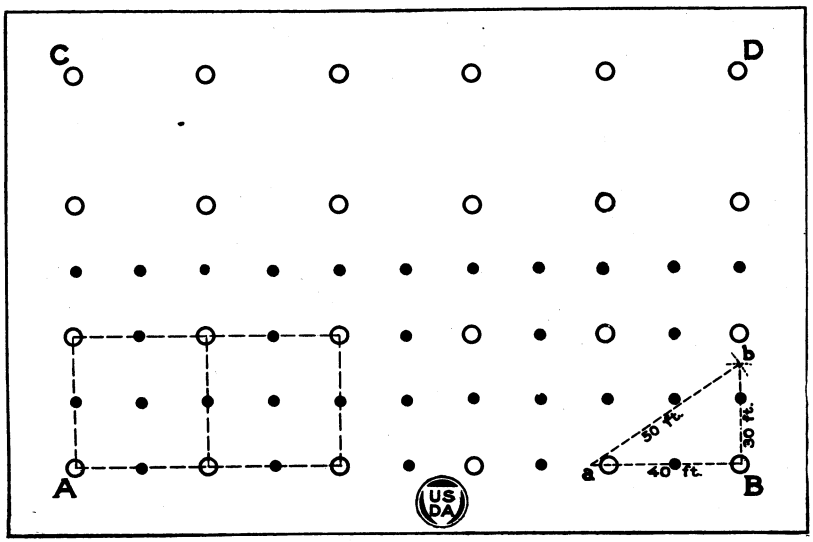


FIG. 14.—Diagram showing the positions of the trees in the square system of planting. The circles represent permanent trees and the black dots interplanted, or filler, trees.

moist fertile soil will produce a larger tree than one lacking in these qualities. However, it is usually impracticable to plant at different distances in the same orchard. The spacing which will best accommodate most of the trees will naturally be adopted.

In some sections apple trees are commonly planted 25 to 28 feet apart each way. With few exceptions, however, this is too close for permanent trees. In several of the older apple sections in the North, 40 feet each way is not uncommon, and even wider spacing is occasionally adopted. Distances intermediate between these extremes are usually preferable, 33 feet (2 rods) and 35 or 36 feet apart being conservative for most conditions. In some of the older apple districts of the North, where growers are familiar with orchards planted many years ago, there is a strong preference for at least 40 feet between the trees.

Temporary, or "filler," trees of early-bearing varieties of apples, or sometimes peach trees, are commonly interplanted between the

permanent apple trees. Such trees may be expected to bear several crops before the permanent trees require the entire space.

PLANTING SYSTEMS.

Several different systems of arranging the trees on the ground with relation to one another are used, each having certain advantages over the others. The systems most commonly recognized are the "square," "quincunx," and "hexagonal."

SQUARE SYSTEM.

Planting on the "square" is the most common system and is generally used when peaches or plums are interplanted among apples. This is so called because any two adjacent trees in a row form a

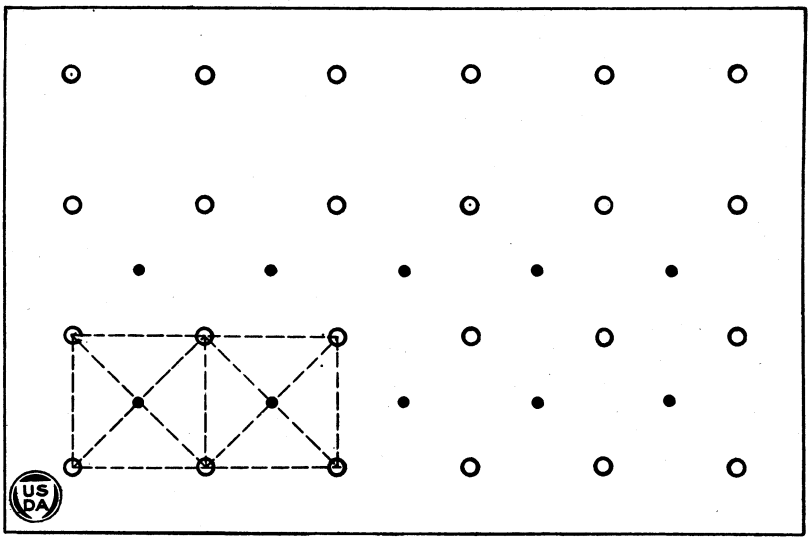


FIG. 15.—Diagram showing the positions of the trees in the quincunx system of planting. The circles represent permanent trees and the black dots interplanted, or filler, trees.

square with the corresponding trees in an adjoining row. This is the simplest system and serves most purposes. The arrangement of the trees according to this system is shown in Figure 14. The center tree of the square may be either a filler apple tree, as discussed in the following paragraph, or a peach or a plum.

QUINCUNX SYSTEM.

The quincunx system of planting, as the definition of the word implies, is where the unit in the arrangement consists of five trees. They are placed in a square, with a tree in each corner and one in the center. The plan is illustrated in Figure 15. It is used principally where fillers are planted. Or, in a gradual removal of filler trees when planted by the square system, the arrangement may become quincunx, when, as in Figure 14, the fillers are removed from the per-

manent tree rows and also every other tree in the solid filler row, thus leaving only the filler in the center of each square of permanent trees. This effect is shown in Figure 15. The quincunx system is

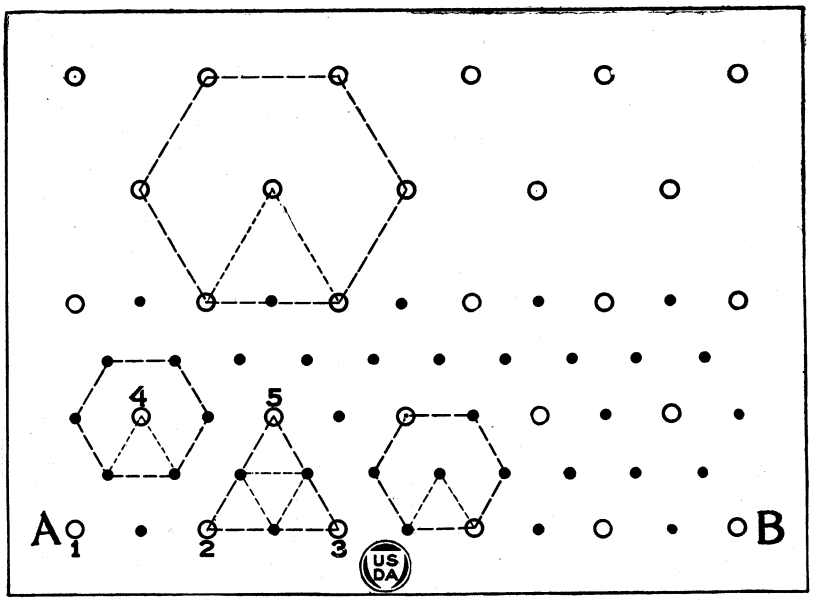


FIG. 16.—Diagram showing the positions of trees in the hexagonal system of planting. The circles represent permanent trees and the black dots interplanted, or filler, trees.

sometimes used when a grower is undecided which of two varieties is preferable. He double-plants, using this system. When he determines which is the more satisfactory variety he removes the other, leaving the permanent trees standing in squares and at the distance apart decided upon when the orchard was planted.

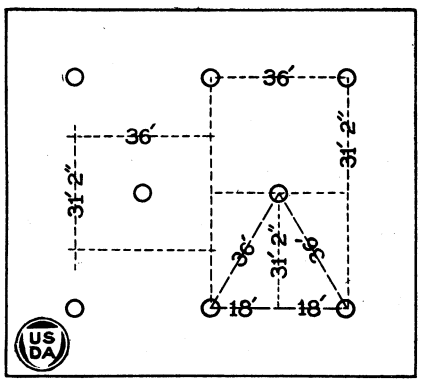


FIG. 17.—Diagram explaining the gain in space of the hexagonal as compared with the square system of planting.

HEXAGONAL SYSTEM.

The hexagonal system is so called because the group figure made by "lining in" the six trees adjacent to any one tree as a center forms a hexagon (a figure with six sides and six angles), as shown in Figure 16. The triangular figures into which each hexagon may be divided have equal sides, and the trees are equal distances apart in all directions (fig. 16).

By this plan the rows are somewhat nearer together than the trees in the row. Thus, as shown in Figure 17, when trees are planted 36 feet apart in the row the rows must be 31 feet 2 inches apart to

produce the hexagonal plan of planting, and each tree, though 36 feet from every other tree, occupies, in effect, a space 36 feet by 31 feet 2 inches, instead of a square 36 feet by 36 feet, as in the square system of planting at these distances. Because of this reduction in the distance between the rows, about 15 per cent more trees can be planted by the hexagonal system on a given acreage than by the square system.

OTHER SYSTEMS.

The only other systems of planting that call for attention here are certain ones used where the site is steep and irregular, requiring that the planting be done with a view to prevent the washing of the soil. This is sometimes accomplished by running the rows according to the contours of the surface, as shown in Figure 18.

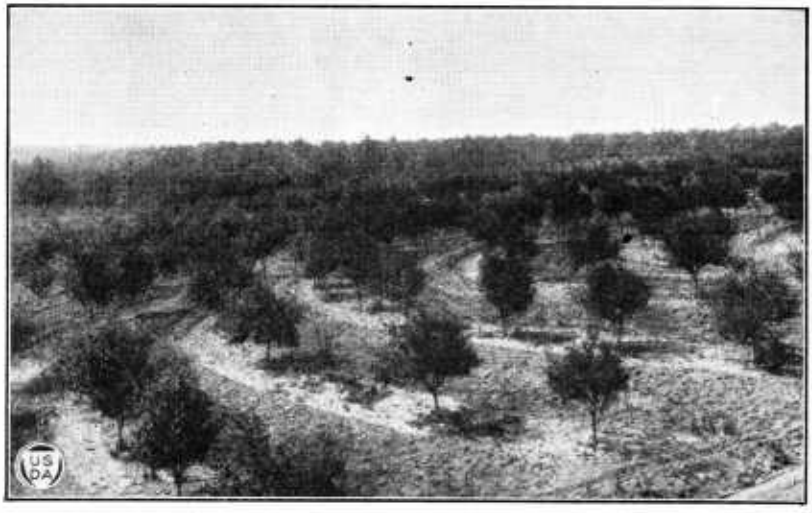


FIG. 18.—Rows of trees shown running with the contour of the land. They are so placed as a means of avoiding the washing of the soil when the orchard is cultivated.

The trees may be spaced at a uniform distance in the rows, but the distances between the rows may have to vary in order to keep each row on its own level. The cultivating is then done between the rows at right angles to the slope, which lessens the danger of washing that exists where the small furrows made by the cultivator run more or less in the direction of the slope. In many cases the terraces are formed gradually in the cultivation subsequent to planting the trees, though they should be started before the planting is done (fig. 13).

Tables 2 and 3 show the number of trees required for planting an acre of land at different distances by the square and hexagonal systems.

TABLE 2.—*Number of trees required for a square acre of apple trees planted at different distances.*[1]

Distance apart.	Number of trees.		Distance apart.	Number of trees.	
	Square system.	Hexagonal system.		Square system.	Hexagonal system.
25 feet	70	79	35 feet	35	41
28 feet	56	64	36 feet	34	39
30 feet	48	56	40 feet	27	31
33 feet	40	46	45 feet	22	25

[1]The number of trees required for an acre is determined by multiplying the distance between rows by the distance between trees in the row and dividing 43,560 (the number of square feet in an acre) by the product. The numbers given in the tables are the nearest full unit in the computation. The exact number which can actually be planted on a given area at a specified distance apart will vary slightly in different instances, depending on the shape of the area to be planted.

TABLE 3.—*Distance between rows for an acre planted according to the hexagonal system with apple trees at specified distances in the row.*

Distance between trees in the row.	Distance between rows.	Distance between trees in the row.	Distance between rows.
	Ft. in.		*Ft. in.*
25 feet	22 1	35 feet	30 4
28 feet	24 2	36 feet	31 2
30 feet	26 0	40 feet	34 7
33 feet	28 7	45 feet	38 11

LAYING OUT THE ORCHARD.

By laying out the orchard is meant the marking of the places on the ground where the trees are to be planted. Whatever the system of planting, the laying out may be done in any one of several ways. Each grower of experience will be likely to develop his own details of procedure. The lay of the land, the system of planting, the facilities at hand, and other factors may determine the method used. The important thing is to make the rows straight and place the trees in the rows so that they check accurately crosswise. The following comments as to methods are merely suggestive.

The details are naturally simplest where the land is level, the square system is adopted, and a surveyor's compass and measuring chain are at hand. With the distances between rows and between trees in the row decided on, laying out becomes simply a matter of sighting in a base row along one side of the field, measuring off the distances between the trees, and driving a stake where each tree is to stand; then repeating for the next row, the position of each succeeding one being determined by measuring the proper distance from the last row staked out.

In the absence of surveyor's instruments the plan suggested by the diagram in Figure 19 may be followed. A border line is established on one side of the field, as *A—A1*, a short distance, 10 or 15 feet perhaps, outside the location of the first row of trees. From this border as a base a square or other rectangular area, depending on the shape of the field, is laid off which includes the main portion of the prospective orchard. This is represented by the square, *A*, *A1*,

A2, *A3*. Distances equal to the distance between the trees in the row are measured off along these border lines and stakes several feet in length driven down firmly to represent the spacing for each tree row. The crosslines I—II and III—IV are marked out with stakes at convenient intervals, the position of each stake, however, being in line with the corresponding stake on the opposite side. If the field is level, these crosslines may be long distances apart; if the ground is uneven, they should be correspondingly nearer together, to aid in sighting over them later on in placing the trees.

To establish the position of the first row, the planter takes a position in the vicinity of *a* and in direct line with the stakes at I and *a3*. He also aligns himself with the stakes at III and *a1*. The point at *a* where these two lines of sight meet when extended is the position of the first tree. The second and all subsequent trees are located in a similar manner, there being always two stakes in each of two directions at right angles to each other over which the planter may sight in lining in the trees. The stakes in the border lines and in the crosslines I—II and III—IV not being on the rows remain undisturbed until all the trees are planted.

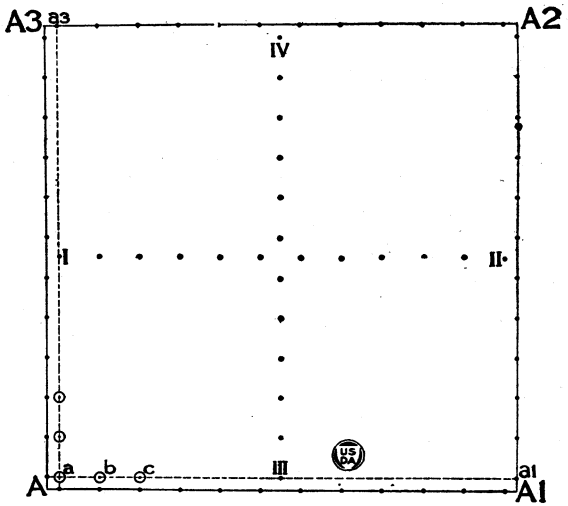


FIG. 19.—Diagram showing the method of laying out land for planting apple trees by the square system.

It is important in laying out the border lines (*A*, *A1*, *A2*, *A3*) to make the corners exact right angles; otherwise serious irregularities in the plan will develop. To accomplish this in the absence of surveyor's or other suitable instruments, proceed as suggested in Figure 14. Measure off in line with *A*—*B* 40 feet (*Ba*); in the other direction measure 30 feet (*Bb*); from *a* measure 50 feet in the direction of *b*. (These distances might be 80, 60, and 100 feet, respectively.) Bring the lines *ab* and *Bb* together at *b* and place a stake where they meet. With these three points, *a*, *B*, and *b*, accurately established the angle at *B* will be a right angle, and the line *Bb* will indicate the exact direction of the line of trees from *B* to *D*. In the same manner the other border lines may be established.

If worked with care this method of determining the corners applied to the laying out of a field, as shown in Figure 19, insures accuracy in placing the stakes by which the trees are sighted into their proper positions.

With these sighting stakes in position it becomes possible at any time to determine accurately and quickly the position of any tree in any row merely by sighting over the corresponding stakes in the base

lines surrounding the orchard and those in the crosslines I—II and III—IV.

If the field to be planted is irregular in outline, the above plan of procedure is still applicable. A square or rectangular area, depending on the shape of the field, is laid out similar to Figure 19. The part inside this area is planted; then the trees in the outlying irregular borders may be lined into position by sighting over the trees already planted.

Where the hexagonal system of arrangement is used, if surveyor's instruments are at hand, the land may be laid out in much the same manner as where the square system is used. Of course, the distances between the rows must be spaced in accordance with the distances between trees in the rows, as suggested in Figure 17, and the first tree in each alternate row drops back half the distance between trees in the adjacent rows. This appears in Figure 16.

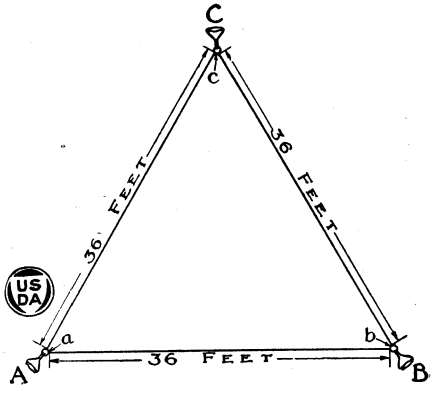


FIG. 20.—A measuring wire, or marker, for use in laying out land that is to be planted by the hexagonal system.

Another simple way of laying out for the hexagonal system is by using such a device as is shown in Figure 20. It is made of a wire (No. 12 or 14 annealed is suitable) or cord that will not stretch. The wire or cord is of such length that when the ends are joined it can be made into the form of a triangle with each side equal in length to the distance between the trees. Figure 20 represents the distance as 36 feet, to conform to the assumed distances in Figure 17. *A*, *B*, and *C* represent handles for convenience in use; *a*, *b*, and *c* are small rings fixed in place through which the tree stakes are to be driven, thus insuring greater accuracy in showing the exact places for the trees than would otherwise be possible.

In using this marker the first row of trees is staked out (*A*—*B*, fig. 16) by the use of any one of the various methods of establishing an outside row. Then three men using the marker or measuring wire (fig. 20) take the corners *A*, *B*, and *C*. *A* and *B* place the rings *a* and *b* over the stakes 1 and 2 (fig. 16). Then *C* (or a helper) drives a stake through *c* (fig. 20) at 4 (fig. 16). Following this, they all move forward, *A* and *B* going to positions 2 and 3, respectively (fig. 16), and *C* drives another stake (at 5, fig. 16) through the ring *c* after drawing the wires taut, thus locating the second tree, 5, in the second row (fig. 16). Proceeding thus, the entire area may be staked out.

Where the ground is uneven or slopes to any considerable extent it is exceedingly important in using a measuring wire, such as the one shown in Figure 20, or in fact in measuring with any kind of line, that it be held level rather than parallel with the ground. If the slope is steep it may be best even to use a plumb bob at the lower end of the measuring line; otherwise the points at which to drive stakes for the positions of the trees can not be determined with accuracy.

In laying out the rows on irregular slopes where the contour is to be followed, a level or some other type of instrument which can be used for leveling is practically essential.

DIGGING THE HOLES FOR THE TREES.

Where the soil has been well prepared and the orchard laid out according to the accepted plan, the making of holes in which the trees are to be planted is largely a matter of detail, though it has important aspects.

The holes should be dug to such depth that when the trees are in place and the holes filled even with the surface the trees will stand about 2 inches deeper than they did in the nursery. This depth is precautionary, since if they are not set quite as deep as they formerly stood they are not likely to stand firmly in the ground or to grow well. Further, the holes should be large enough across so that the tree roots will not be bent or twisted from their normal positions.

Sometimes the hand labor in digging the holes is lessened by making a furrow along the line of each row, running a plow several times in the same furrow if necessary in order to make it large enough for the roots. This course calls for staking out the rows in such manner that the man with the plow will have adequate guides to enable him to make the furrows straight.

BLASTING THE HOLES.

The use of dynamite in blasting the holes consists in exploding about half a cartridge of 20 per cent or other low-grade dynamite at the point where each tree hole is to be made and at a depth of 2½ to 3 feet, depending on soil conditions. The explosion is produced by the use of a fuse and percussion cap, as for other purposes.

The claim is that the explosion shatters the subsoil, thus making better conditions for the growth of the roots. Carefully conducted experiments have given widely different results, some being favorable, others indifferent or detrimental. In some cases apparently favorable results in the growth of the trees for the first few years have disappeared within a comparatively short time, in contrast with trees planted in the usual way.

While dynamite undoubtedly has its place in preparing the holes, it needs to be used with discretion and as a method to meet special conditions rather than as a regular practice.

Perhaps the one unquestioned use of dynamite in tree planting is where there is a stratum of hardpan near the surface and the subsoil below it is suitable for orchard purposes. If the hardpan is broken up with dynamite so that the roots can get below it, conditions with respect to tree growth are likely to be permanently improved.

It is generally recommended that dynamite, if employed at all, be used some time in advance of the time of planting, so that the soil will settle before the trees are put in position.

SETTING THE TREES.

As received from the nursery the roots of trees are usually more or less broken and mutilated. Before they are placed in the holes the broken ends should be trimmed off smoothly and the mutilated parts cut away. If there are any long slender roots, they are usually cut back to conform to those which comprise the general root system.

The subsequent details may vary considerably, as convenience and conditions suggest. The trees may be distributed by hand from the place where they are heeled in or otherwise held, or from a wagon, as convenience dictates. Whatever the method used, the roots must be protected constantly so that they will not become dry. For this reason they should not be distributed much in advance of the time of planting. Sometimes the roots are puddled to protect them from drying out. This consists in dipping them in thick clayey mud. Enough mud will adhere to the roots to afford considerable protection in case they should be exposed for a short time to the sun or to drying winds.

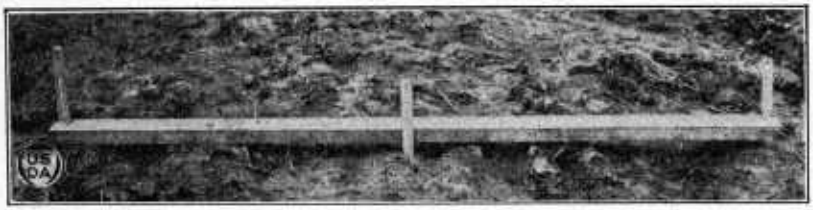


FIG. 21.—A planting board in its first position. The center stake marks the place where the tree is to stand.

PUTTING THE TREES IN POSITION.

As each tree is put in position it should be perfectly aligned, in order that the row when completed may be straight and so that the trees will check properly crosswise the rows or diagonally as in the hexagonal system. If the planting crew consists of three men, the trees may be aligned by sighting over those already planted (after the work is fairly under way) and the guide stakes which were put in place to indicate the position of the borders when the land was laid out. Three men, one to handle the tree and two to do the aligning, one sighting in each direction, make an efficient arrangement.

If less than three men work as a planting crew or where only a small number of trees is concerned, a planting board (fig. 21) is helpful. Before a hole is dug the board is so placed that the stake marking the position of the tree comes in the notch in the middle of the board. A stake is driven at the notch in each end, the board then taken up, and the hole dug. In setting the tree, the board is returned to its original position, as indicated by the two end stakes which are undisturbed, and the tree so placed that its trunk comes in the middle notch, as did the stake which marked the position of the tree (fig. 22).

In planting in a very windy place it is common practice as the trees are placed in position to lean them 10° to 15° toward the quarter

from which the wind prevails, in order to counteract as far as possible the misshaping effect of the wind on the growth of the trees.

FILLING THE HOLES.

In filling the holes after the trees are placed in position, finely pulverized topsoil should be used. The soil is worked in among the roots, completely filling the spaces between them. This can be done best with the fingers. It will help also if, when the hole is partly filled and before the soil has been packed at all, the tree is moved very slightly up and down. This movement serves to settle the soil still more completely among the roots. Following this, the soil must be packed firmly in the hole as the filling progresses, using the feet or a tamper, such as is shown at the right in Figure 22. The holes finally are filled even with the surrounding surface.

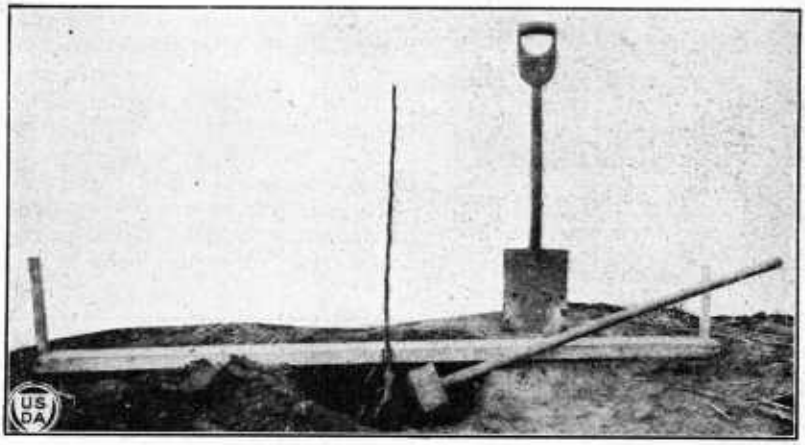


FIG. 22.—A planting board in its second position. The hole has been dug, and the tree is now where the center stake formerly stood.

PRUNING THE TOPS OF TREES.

The tops of the trees as well as the roots need to be pruned when planted, not only to shape them properly with regard to their future development but to equalize the tops in some degree with the roots, which are always considerably reduced when the trees are dug. The shaping of the tops may be done either before or after the trees are planted, as may be preferred. In case of fall planting, the branches that are selected for the framework, or scaffold (as these branches are termed), of the permanent top are sometimes left a few inches longer than they are intended to be permanently, because of the possibility of the ends killing back during the winter. The final pruning is then done in the spring with little additional expense.

The manner in which the tops are pruned and shaped at the time of planting depends on the trees and the ideals and plans of the grower. A 1-year-old tree should be headed back, as shown in Figure 22, at the height which it is desired the head shall form, usually from 24 to 30 inches from the ground. In some of the extremely cold regions heads formed within 12 to 18 inches of the ground are pre-

FIG. 23.—A 2-year-old apple tree pruned when planted as here shown will normally develop a very dense top. Some growers prefer this type of tree to others.

ferred by some, with the conviction that the trunks are better protected against injury from extreme conditions.

A 2-year-old tree is usually pruned with a view to developing either an open-center top or one having a central leader. However, two other types or plans of top are sometimes recognized—a modified central leader, as it has been termed, and a dense-centered top without special designation. The latter form is local in its use and generally not to be recommended. It is developed simply by cutting back all the limbs of a heavily branched 2-year-old tree without any thinning out. Such a tree after being pruned is shown in Figure 23. The normal course of development of a tree so pruned results in a very dense top, as shown in Figure 24.

In starting a tree to be pruned to an open center, from three to five of the most uniform branches

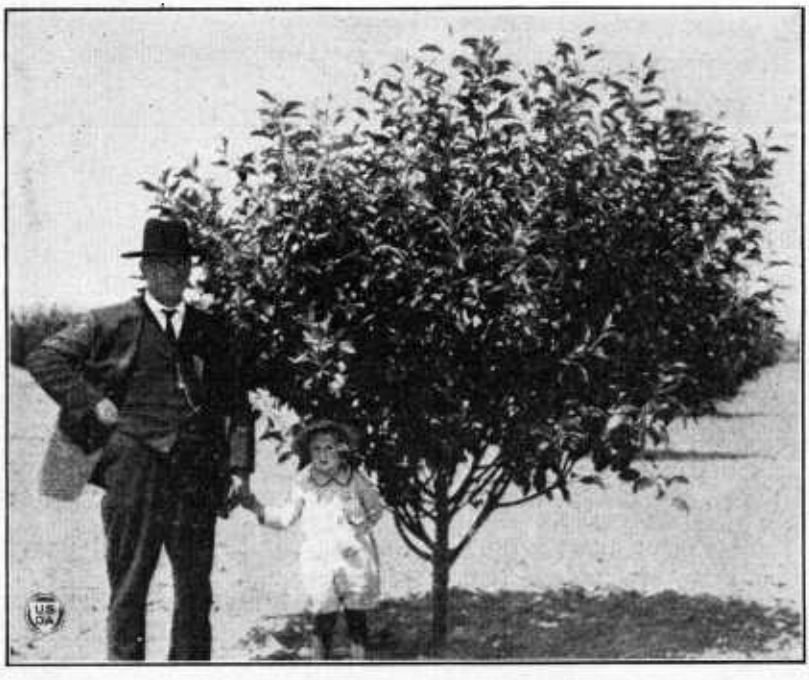


FIG. 24.—An apple tree in its fourth season that was pruned when planted, as shown in Figure 25. The top is much more dense than is desired by most apple growers.

are selected for the framework and the others removed. Those selected should be as evenly distributed as possible about the stem of the tree and so placed as to avoid the making of bad crotches. The distance between the branches up and down the trunk is important. If too close together or if they branch from the trunk at or near the same level but on opposite sides a weak top with limbs likely to split down will result. The limbs selected for the permanent top (the scaffold branches) are usually cut back from one-third to one-half their length or even more in case of strong, vigorous 2-year-old trees. A well-branched tree with pruning indicated for the open-center plan of development is shown in Figure 25.

In shaping a tree with a central leader, the procedure is the same as for an open-center tree except that a single branch, the one that most nearly represents the upward extension of the trunk, is left considerably longer than the others or without being cut back at all, as shown in Figure 26.

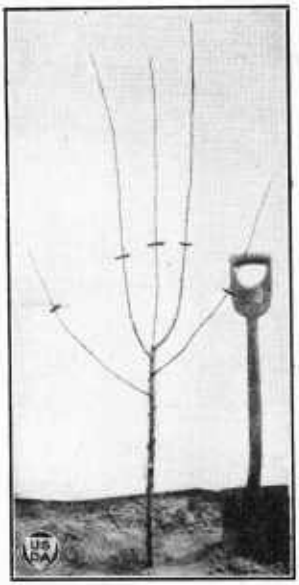


FIG. 25.—A 2-year-old Stayman Winesap apple tree. The cross lines suggest the approximate points at which to cut back the branches when the tree is planted if it is to be developed with an open center.

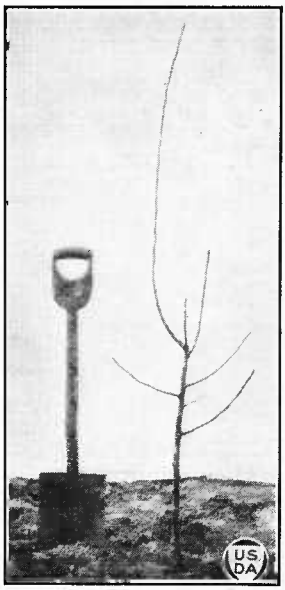


FIG. 26.—A 2-year-old Stayman Winesap apple tree pruned with a central leader when planted.

The modified central-leader plan is a comparatively new conception. In some respects it is intermediate between the open-center and the central-leader plans of development and has certain of the desirable features of each. When pruned at the time of planting the same plan is followed as in pruning a central-leader tree, except that the central leader is left only a very few inches longer than the side branches. This is sufficient to give that branch a slight advantage over the others when the tree starts into growth and during the first season after planting.

As the top of a 1-year-old tree develops it is pruned the same as a 2-year-old, according to the system preferred by the grower.

FIG. 27.—An apple tree in its second season of growth following planting as a 2-year-old tree. The limbs were not cut back when it was planted. Growth took place from the terminal buds, and practically no side buds developed branches. No cutting back was done following the first season's growth. At the beginning of the second season the terminal buds again put forth new growth, with very few side buds developing branches. The result is a very "leggy" top. Had a reasonable amount of cutting back of the branches been done, side buds would have developed branches and a compact but well-formed head would have resulted. Some varieties develop side branches more than others, even though no cutting back is done.

The system of development which a grower selects should depend on how he plans to prune his trees in after years, though to some

extent there may be regional preferences and practices. The natural habits of growth of different varieties should also be considered.

While most growers planting 2-year-old trees cut back the scaffold branches, as above described, with one of the several systems of pruning in view, some claim better results where the branches are not cut back; others prefer to cut back a portion of those selected for the permanent top, leaving the rest full length. This course recognizes the fact that when a tree renews its growth, following the dormant period, the buds at the ends of the branches start first and are the first to develop full-sized leaves. This early growth of leaves is looked upon as important in reestablishing newly planted trees. However, the practical good following this course probably depends somewhat on the variety and its habit of growth. Some varieties normally branch but little, and the limbs they develop from year to year with no cutting back would soon become too " leggy " to be of practical use in supporting a crop of fruit (fig. 27).

DIFFERENT SYSTEMS OF ORCHARD CULTURE.

Several systems of orchard culture are in common use, such as clean tillage, tillage and interplanted crops, tillage and cover or green-manure crops, sod culture, mulch, and combinations and modifications of these systems.

Cultural methods affect the soil in its relation to the growth and productiveness of the trees. This relationship has to do mainly with plant foods and moisture. The system that is the best at one period in the life of an orchard may not always be the best one. The behavior of the trees or the conditions with which he has to contend should be the grower's guide as to the best system for him to employ. If the trees are healthy, foliage of good color, annual growth satisfactory, crops regular and abundant, and the costs of maintenance not out of proportion to the returns, the evidence is convincing that the system used is measurably efficient. If the orchard is faulty in any of the above standards of performance, the evidence should be convincing, other things being provided for, that a change is needed.

THE PLACE OF CULTURAL SYSTEMS IN ORCHARD MANAGEMENT.

A grower should understand the general effect of the different cultural systems, so that he may know which one best meets his own needs. The following statements present rather broad facts in this connection.

CLEAN TILLAGE.

By clean tillage is meant the more or less frequent use of harrow or cultivator in the orchard, beginning in early spring and continuing until midseason. However, clean tillage may mean to one grower the plowing of the orchard in the spring and perhaps one or two cultivations later on. To another it may mean cultivating or harrowing the soil every 10 days or two weeks from early spring till the middle of July. The first working of the soil in the spring may be by plowing, disking, or harrowing, depending on its condition. Plowing as a rule should be shallow or at least so gauged as to depth as to avoid cutting off the tree roots in any considerable number.

Clean tillage frequently applied has long been emphasized as a means of conserving soil moisture through the influence of the dust mulch which it creates, the mulch supposedly preventing the evaporation of moisture at the surface of the soil. More recently, emphasis has been placed on frequent tillage as a means of destroying weeds, the view being that the growth of weeds is the chief cause of loss of moisture and that very little is lost by evaporation as a result of the rise of moisture to the surface through the action of capillarity in the soil. With this understanding of the function of clean tillage in conserving soil moisture, the way appears for avoiding certain ill effects recognized as accompanying the presence of a dust mulch on the surface of the soil. Every experienced tiller of the soil knows with what great difficulty a dry layer of dust or other finely divided material on the surface of the soil or elsewhere (as, for example, a pail of dry meal or flour) absorbs moisture. He has observed that a dust mulch often prevents the free penetration of water in the form of showers and rains into the lower depths of the soil and that it frequently increases the run-off, because the rain is not readily absorbed, and this may result in gullying. Therefore tillage should be directed to keeping the soil free from weeds, and the surface

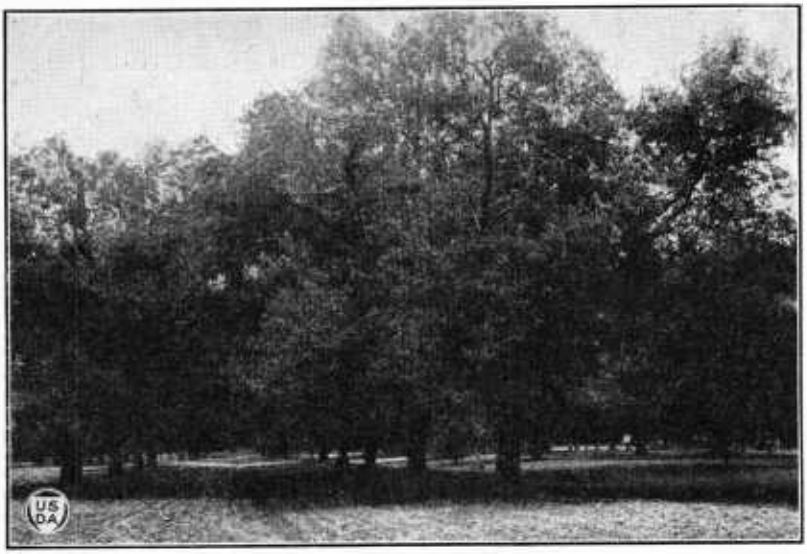


FIG. 28.—A well-cared-for orchard where clean tillage has been practiced which has resulted in a mulch of finely pulverized soil on the surface.

not in the condition of a dust mulch but rather in a granular or very fine lumpy condition, which readily absorbs the rainfall and apparently accomplishes all that a dust mulch does in preventing evaporation at the surface.

This conception of tillage in its relation to soil-moisture conservation, as here briefly outlined, is based on long-continued and extensive studies of the soil-moisture factor and related problems in the Office of Dry-Land Agriculture Investigations of the Bureau of Plant Industry. This treatment provides also for the aeration of the soil and helps to maintain conditions that are favorable for the chemical and other activities which are necessary to keep up its fertility. An orchard maintained under clean-tillage methods is shown in Figure 28.

TILLAGE AND INTERPLANTED CROPS.

The essential difference between the interplanted crop system and clean tillage is in the planting of certain crops in the space otherwise vacant between the rows of trees. This system may be used in young orchards up to the time they come into bearing provided the soil was in good condition when the trees were planted. As a rule, after the trees begin to bear they ought to have the entire space without competition with other crops.

Interplanted crops may be selected with reference to their salability when produced and their market value, as well as with respect to their relation to the more important and permanent crop—the apple trees. Interplanted crops must be those which require essentially the same tillage as the trees—beans, cabbage, peas, tomatoes (perhaps for a cannery), or other hoed crop having similar tillage requirements. Potatoes, if harvested early (before the tillage season is past) or late in the autumn (after the trees become thoroughly dormant), may be used. Corn is much used as an interplanted crop, but the practice too often prevails of planting the rows so close to the trees that the stalks shade them badly before the end of the season. The sowing of the small grains, other than for cover or green-manure crops, is not to be advocated. Small-growing or early-bearing varieties of apples, such as Yellow Transparent, Wealthy, Wagener, and others, are frequently interplanted as fillers between the permanent apple trees; peach trees are sometimes planted in the same way.

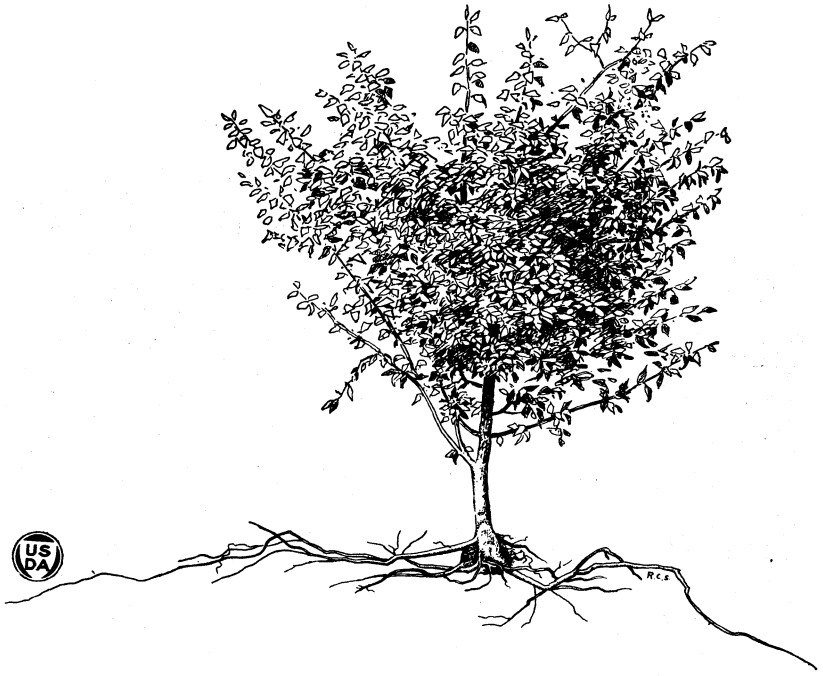


FIG. 29.—A Stayman Winesap apple tree which was planted as a 1-year-old. It is one of the trees shown in Figure 10. It was not cut back when planted, nor has it had any pruning since. It was dug up for an examination of the root system in the midseason of the fourth summer after it was planted. Only a few of the main roots are here shown, a large network of other roots being destroyed in tracing through the soil the ones shown. The expanse of the roots was found to be about 10 feet as they were traced, with other very small hairlike roots extending some distance farther. Borers had injured the tree at its crown on the opposite side from that shown, and as a result but very few roots had developed on that side.

The fact that interplanted or secondary crops may compete with the tree roots comparatively early in the lives of the trees is suggested by the root system of the tree shown in Figure 29. This tree was in its fourth season's growth and had a root expanse of about 10 feet.

TILLAGE AND COVER OR GREEN-MANURE CROPS.

The terms "cover crop" and "green-manure crop" are frequently used to mean the same thing. While each may serve the purpose of the other, the main object for which each one stands is distinct. A cover crop is one of such character that it will cover the ground during the winter, this being its primary purpose. The protection of the tree roots against extreme freezing by the use

of such crops is sometimes of great importance; also, in the South, the shading of the ground during the hottest part of the season may be desirable.

A green-manure crop is one that is grown primarily for the improvement of the soil either by adding humus or nitrogen or both.

The tillage and cover or green-manure crop system is perhaps the most nearly ideal of all and the one generally to be used as a standard by which the effectiveness of others can best be judged. This system possesses the advantages of clean tillage in conserving moisture and bringing about conditions favorable for chemical changes and the activities of soil bacteria and other organisms which result in making plant food available. It also provides for keeping up the supply of humus in the soil.

Plants used for cover or green-manure crops fall into two groups—leguminous (or nitrogen gathering) and nonleguminous. The former group comprises red clover, crimson clover, bur clover, field peas, hairy vetch, cowpeas, and others; the nonleguminous group consists of rye, oats, buckwheat, rape, turnips, and various others. Sometimes the growth of weeds is encouraged after the seasonal cultivation is ended as a means of obtaining a cheap supply of vegetable matter for the soil. The grower will need to consider his own needs and the conditions to be met in deciding which crop to use. Generally speaking, the best cover crop is the one which in the locality grows best and gives a heavy growth of vegetable matter to turn into the soil. Price and availability of seed are also factors to be considered.

Red clover is commonly used in sections to which it is adapted when it is intended to maintain the orchard in sod for a time. Hairy vetch is apparently being used more and more as an orchard cover crop. Cowpeas and soybeans are very widely used for green-manure crops in middle and southern latitudes.

Probably rye is the most widely used nonleguminous plant for cover-crop purposes. It can be sown late in the season, it lives over winter, and it starts into growth early the next spring. Rye and hairy vetch are commonly used in combination.

Where an annual cover crop that lives over winter is used it should be plowed under as early in the spring as practicable unless the growth that is on the ground can be worked into the soil effectively and more conveniently by the use of a disk or cutaway harrow. If there is an abundance of moisture in the soil, the turning under of the cover crop is delayed in many cases until after it has made considerable growth in the spring, in order to obtain as large a quantity of vegetable matter to be worked into the soil as is possible. On the other hand, where summer rainfall is low caution must be exercised not to delay turning under the cover crop until it has robbed the soil of moisture, which should be conserved early in the season for the use of the trees later on.

Though cover and green-manure crops are commonly sown in midseason, when the orchard is given its last cultivation for the year, they may need to be put in relatively earlier in the North than in the South because of the difference in the length of the growing season. The seed may be broadcasted, put in with a grain drill, or perhaps in the case of cowpeas or soybeans the seed may be planted in rows 3 feet apart and cultivated for a time. This results in a growing season sufficiently long to mature a seed supply for the next year and still not deprive the trees of the benefits of tillage.[3]

SOD CULTURE.

The terms "sod culture" and "sod mulch" as used in apple-orchard management have come to be loosely applied. In general, they are commonly used in referring to almost any method of maintenance whereby the orchard receives no tillage. However, two rather distinct systems are, in fact, included under this term. Strictly applied, the sod-culture system is where the orchard is maintained in sod, the grass being mowed several times each season and allowed to remain where it falls to serve as a mulch or cured for hay. Not infrequently, as in the case of alfalfa, one or more of the cuttings are made into hay and

[3] The quantity of seed of the various cover crops commonly sown per acre is as follows: Red clover, 10 to 15 pounds; crimson clover, 12 to 16 pounds; bur clover, 20 pounds; field peas, 1½ to 2 bushels; hairy vetch, 25 to 30 pounds; common vetch, 40 to 50 pounds; cowpeas, 1 to 2 bushels; soybeans, 1 to 1½ bushels; rye, 1½ to 2 bushels; oats, 2 to 2½ bushels; buckwheat, 1 bushel; millet, 1 to 1½ bushels; rape, 3 pounds; turnips, 3 pounds.

the others used as a mulch. When the soil is in good condition, the soil moisture abundant, and the growth of the crop vigorous, the latter course may be practicable. However, leaving all the vegetation on the ground as mulch and not haying any of it is favored by many growers.

The permanent sod commonly consists of one of the several clovers (within the limits of its persistence), and June-grass or some of the other fine grasses. Sometimes an orchard may be seeded to clover, and the fine grasses will come in sufficiently without seeding by the time the clover runs out. However, the wisdom of continuing an orchard in sod longer than three or four years at a time is a debatable practice except where it is done for some very special reason.

The other system commonly covered by the term "sod mulch" is where only a relatively small quantity of grass is grown in the orchard either because of the shade of the trees as they attain large size or for other reasons, the owner supplying the necessary mulch by spreading over the ground straw, swale hay, or some other kind of suitable vegetation free from weed seeds.

In many places a strictly mulch system is impracticable because of the lack of available material suitable for use as a mulch.

COMBINATION OF DIFFERENT SYSTEMS.

In general, each of the several systems of culture has its advantages as well as its disadvantages. In some cases a grower may find it practicable to combine different systems. For example, he may maintain a sod in each alternate space between tree rows, using clean tillage or tillage and a cover crop in the other spaces. After a short period of years the practice may rotate, using tillage in the spaces formerly in sod and cultivating the others.

TILLAGE IMPLEMENTS.

Tillage implements used in the orchards—plows, harrows, cultivators, and the like—may be the same as are found satisfactory in working the same type of soil for general farm crops. Obviously, light rather than heavy plows are usually preferable, and there are certain makes of harrows with extension heads which as compared to ordinary implements permit a more convenient working of the soil under low-hanging limbs. Other special orchard harrows are to be had and may be convenient where extensive operations are concerned, but their usefulness for other farm needs, where the orchard is only one of several enterprises, may consistently be taken into account when purchasing. Under some conditions a heavy disk or cutaway harrow having very large blades can be used effectively instead of a turning plow. The latter will sometimes catch under roots of considerable size, pull them up, and tear them from the tree before the team or tractor can be stopped. The disk plow also has its place in orchard tillage. The duck-foot type of cultivator is a desirable implement with which to make a granular rather than a dust mulch. It may be noted that tractors are coming into use in orchard work rather rapidly.

USE OF FERTILIZERS.

In the use of commercial fertilizers the apple grower is concerned primarily with nitrogen, phosphorus, and potash, the plant foods contained in a complete fertilizer. Other plant-food elements may be involved sometimes, but as a rule they are not considered.

In commercial forms of plant food, nitrogen may be carried in nitrate of soda, sulphate of ammonia, tankage, cottonseed meal, and other compounds; phosphorus or phosphoric acid in bone meal in various forms, and in finely ground rock phosphates either "raw" or acidulated (acid phosphate); potash largely in the

form of muriate or sulphate of potash. Kainit is a crude form of potash mixed with various other substances.

What constitutes an economical or profitable application of plant foods (fertilizers), however, is a matter that can not be stated in concrete terms. A fertilizer containing certain plant foods which proves the best for one orchard may show no response if applied in some other orchard with different soil conditions.

A soil that lacks humus is in poor physical condition and is necessarily unproductive, without regard to the plant food it may contain.

In an orchard where the soil is otherwise productive but the crop is limited because of the lack of a certain element of plant food, for example, nitrogen, and yet other plant foods are abundant, productiveness would be expected to improve if the necessary nitrogen was supplied. In such a case the application of other plant foods (phosphorus or potash) would bring no response, and it would be a waste of money to use them.

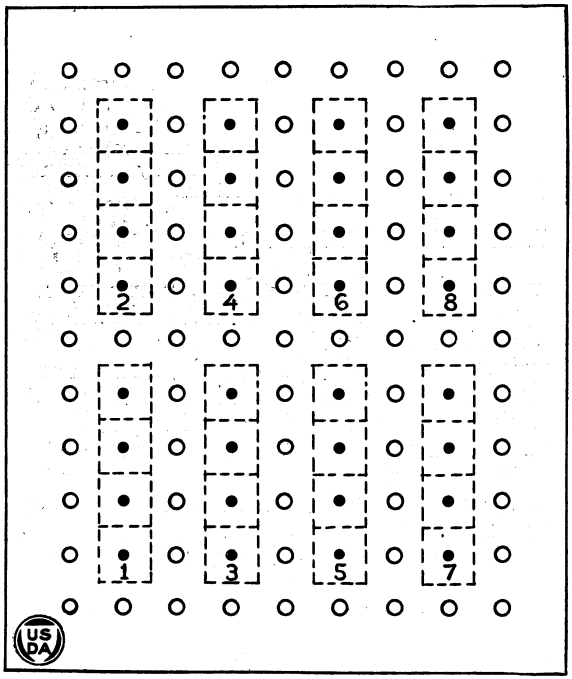


FIG. 30.—A ground plan for a simple fertilizer test in an apple orchard arranged for the purpose of demonstrating what plant foods the grower should apply.

In like manner, potash or phosphorus might be the "crop limiter," because of an inadequate supply in the soil, or one plant food (either nitrogen, phosphorus, or potash) may be abundant and the other two lacking.

Since soils vary with respect to the available plant foods which they contain, depending on their origin, physical condition, the way they have been cropped and managed in previous years, and on other features also, it necessarily follows that each orchard presents its own peculiar fertilizer problems. If only one or two plant foods are lacking, it is not economical to apply a complete fertilizer.

A chemical analysis of the soil does not answer the question as to what is lacking. Such an analysis might show the actual content of plant-food materials, but it would not tell what the apple trees growing in the soil could get out of it. A part of the plant foods revealed by the chemist to be present may be (and usually is) locked up in such chemical combinations as to be unavailable to the roots of

the trees. The chemist is unable to determine how much of what he finds to be present the trees can take up.

The grower's best recourse for getting information regarding the plant-food needs of his particular orchard is to carry on a demonstration in a representative section of his orchard, planned with that end in view. Such a plan is outlined in the diagram in Figure 30. In this diagram each group of black dots is intended to represent four trees receiving a different combination of plant foods, with suitable checks which receive no fertilizer of any kind.

Nitrogen, phosphoric acid, and potash are the plant foods which need to be considered. For the purpose of the demonstration these may be used, respectively, in the form of nitrate of soda, acid phosphate, and muriate of potash.

Each group (fig. 30) should consist of at least four trees (a larger number would be better), and in order to prevent uncertainty of results each group should be surrounded by untreated trees. The annual applications suggested for each tree in the different groups are as follows:

Group 1. Nitrate of soda, 5 pounds; acid phosphate, 5 pounds.
Group 2. Nitrate of soda, 5 pounds; muriate of potash, 2½ pounds.
Group 3. Check (no fertilizers).
Group 4. Acid phosphate, 5 pounds; muriate of potash, 2½ pounds.
Group 5. Nitrate of soda, 5 pounds; acid phosphate, 5 pounds; muriate of potash, 2½ pounds.
Group 6. Check (no fertilizers).
Group 7. Nitrate of soda, 10 pounds; acid phosphate, 10 pounds; muriate of potash, 5 pounds.
Group 8. Stable manure, 500 pounds.

The above arrangement is suggestive only and admits of many modifications. The quantities of the different plant foods suggested are about as used by the Ohio Agricultural Experiment Station in its extensive orchard rejuvenation work in southeastern Ohio. The Pennsylvania station in its very comprehensive apple-orchard fertilizer experiments has used generally 8 or 10 pounds per tree of acid phosphate with 2 pounds of muriate of potash and 5 pounds of nitrate of soda.

If the simple plan of arrangement suggested in Figure 30 is followed, 32 trees will be included in the demonstration, or slightly more than an acre of orchard if the trees stand 36 feet apart each way. Of these trees 24 only will receive applications of plant food. The two check groups (Nos. 3 and 6) and the trees between the different groups are untreated. Plant-food materials, nitrate of soda, acid phosphate, and muriate of potash will be applied in the various combinations to 20 trees; stable manure will be used on 4 trees. For this number of trees at the rates mentioned the various materials will be required in the following quantities: Nitrate of soda, 100 pounds; acid phosphate, 100 pounds (or 200 pounds if the larger quantities used in the Pennsylvania experiments are applied); muriate of potash, 50 pounds (or 40 pounds if but 2 pounds to the tree is used, as in the Pennsylvania work).

It has been found by several different experiment-station investigators that the time of making the application is important, especially in the case of nitrate of soda. If applied about as the buds are starting in the spring the nitrogen may produce a response in the current season's crop, while if delayed until the blossoms

have fallen and the fruit has set it seems to be too late to affect the current season's crop, though it may be apparent later in the color of the foliage. Early applications of nitrogen may also have considerable influence on annual bearing because of the stimulating effect on the growth and development at that period of a part of the fruit spurs.[4] However, if the slower acting forms of nitrogen are used and the usual forms of acid phosphate and potash, little effect of the fertilizer should be expected before the next season. Some recommend dividing the nitrate of soda, making an application of a portion of it three or four weeks after the trees blossom rather than applying the entire quantity earlier. This advice applies especially if a total of 5 to 8 pounds per tree is to be used, as is sometimes done with large trees.

While results may be indicated the second season and be even more evident the third season, probably the demonstration should be continued at least five years for final results.

The interpretation of the results is a simple matter, yet it requires careful observation. The growth made by the trees, the color of the foliage, the size of the crops, the grade of the fruit, and the regularity of production are all essential points to observe.

In studying the different groups the unfertilized checks (groups Nos. 3 and 6) serve as the basis of comparison by which the results of the groups differently fertilized become evident. The fertilized groups are also to be compared with one another. Thus, if the limiting factor is lack of potash, it should be made apparent in better results from group No. 2, which receives muriate of potash, as compared with either group No. 1 or one of the check groups which receive no potash.

If a lack of available phosphorus in the soil is limiting production, the results from group No. 1 should be better than from group No. 2 or the checks which receive no acid phosphate. Besides, the results of group No. 4 should compare favorably with either group 1 or 2, depending on whether phosphorus or potash is most needed; and if nitrogen is the limiting factor the results of groups Nos. 1 and 2, which receive nitrate of soda, should contrast strongly with the two check groups (Nos. 3 and 6) and group No. 4, which do not receive it. Group No. 5 receives a complete fertilizer, that is, all of the three fertilizing materials used, and group No. 7 is a duplicate of group No. 5 except that it receives double the quantity of fertilizer. This group is of importance only as it throws light on the quantity of the different materials that can be used most economically.

It should be stated in this connection that where nitrate of soda is used liberally one of the results is usually to delay the ripening of the fruit and therefore its coloring. By delaying the picking of the fruit on the nitrogen-fertilized trees until it is as ripe as that gathered from the trees in the check group, the color differences will usually disappear. The highly beneficial results in terms of fruit production from the use of nitrate of soda (nitrogen) in recent years, both by experimenters and commercial apple growers, have served to place a new emphasis on nitrogen as a plant food in apple orchards.

[4] Roberts, R. H., Off-year apple bearing and apple spur growth. Wis. Agr. Exp. Sta. Bul. 317, 34 p., 13 fig. 1920.

A demonstration such as the one described may be made in orchards managed under any of the various systems of culture. In mature orchards the fertilizing materials are usually applied broadcast early in the spring over the area represented by the dotted lines surrounding the different groups of trees, as shown in Figure 30. This will vary with the size and age of the trees. If the trees are only just coming into bearing the feeding roots may not have reached the center of the space between the rows, though they often extend much farther than is commonly supposed. The fertilizers do not need to be put within several feet of the trunks of the trees, as the feeding roots are mostly at the extremities of the root system. Figures 29 and 31 emphasize the fact that the extremities of the root system are not confined to the area covered by the spread of the branches, as is commonly supposed.

FIG. 31.—The root system of a Ben Davis apple tree about 14 years old grown under semiarid conditions at Cheyenne Wells, Colo., in the foreground. Roots were traced 26 feet on one side and 9 feet on the other. The tree was similar in size and appearance to those seen in the illustration. The feeding roots were far away from the trunk of the tree. The roots extend where they find moisture and plant food.

PRUNING.

Pruning is one of the essential operations in successful apple growing, yet perhaps there is more diversity of opinion and practice among growers with regard to it than with respect to any other operation in the orchard.

The facts probably are that certain ends are accomplished by this operation and when performed without unduly disturbing the functioning of the different parts of the tree that are affected, there is considerable latitude as to details.

The pruning of an apple tree divides into three more or less well-defined periods: (1) The first two or three years it has to do mainly with shaping the tree and developing it with regard to the greatest possible mechanical strength of the limbs and other parts. (2) From about the third year to the bearing age pruning should be directed more especially to future fruit production. This is a critical period, since the manner in which a tree is pruned may materially hasten or retard the time when it will begin to bear. (3) The final period covers the remainder of the life of the tree, when pruning should be done mainly with regard to its effects on the thrift, vigor, and productiveness of the tree and the perfection of the fruit.

It should be obvious, since no two trees grow alike, that pruning can not be done by rule; that the pruning of a tree planted on fertile soil and where the conditions for a rapid vigorous growth are favorable is quite a different matter from performing the same operation on a tree planted where the conditions for growth are adverse.

The pruner should keep in mind the fact that the top of a tree is not a single individual, but that it is, in effect, a community of individuals, each bud being potentially a unit. In this tree-top community there is an intense struggle for existence, each bud competing with its neighbor for elaborated food materials, sunlight, and space.

It naturally follows that the effect of pruning is local within certain limits. While heavy pruning affects the entire tree, that which is done on a single limb or on a fruit spur affects primarily the behavior of that limb or spur and concerns but little the rest of the tree. Therefore, the fruit spurs and smaller limbs are likely to be modified by small local cuts rather than by the making of correspondingly few large cuts, as, for example, in the removal of a few large limbs.

In pruning, the best ends are gained by doing relatively little each year rather than correspondingly more at less frequent intervals. This annual pruning, which is for the purpose of keeping the trees properly shaped and within bounds, the top well opened, and a proper balance between growth and fruit-bud formation, should be done during the dormant season, preferably in late winter or early spring before growth starts. It is then only a short time before the wounds begin to heal. However, where there is much to be done growers usually take whatever chance of ill effects there may be and prune throughout the winter whenever the weather is favorable and as the urgency of the work requires.

The pruning of the trees at the time of planting has been considered in connection with that operation (see p. 25).

DETAILS OF PRUNING DURING THE FORMATIVE PERIOD.

THE FIRST YEAR.

A tree planted as a 2-year-old, whether started with an open center or a central leader, should make considerable growth during the first season. The limbs selected for the scaffold of the top when the tree was planted will likely have developed several branches; perhaps other branches also will have developed from the trunk by the end of the season.

When the tree is pruned following the first season's growth, the branches that are produced during this first growing season on the scaffold limbs should be selected with a view to keeping the top uniform and well balanced, and as a rule not more than two should be allowed to remain on each limb; the others, if more have developed, should be cut away entirely. Then those that were reserved are cut back, usually one-third to two-thirds of their length. However, in actual experience not all the original scaffold limbs will develop two branches so placed as to make it desirable to retain them.

Another condition will sometimes be met. The tree during its first season may not make very much growth, though it will become well established in its permanent position. In this case, pruning will

consist in heading back slightly and the removal of small branches which, if allowed to develop another year, would destroy the general plan of the tree.

A central-leader tree should be pruned very much as above described, the central branch still being so shaped as to maintain its lead over the surrounding limbs. During the first season additional limbs may have developed from the central leader at points above those that were selected when the tree was planted. Possibly two or three such branches can be retained if they are considerably above the original scaffold branches.

A modified central-leader tree will normally develop during the first season much as a central-leader tree does, and it should be pruned in about the same manner. Presumably several side branches will have developed on the leader. If one or more of these are well placed with respect to the scaffold limbs they should be retained and any others cut off. The central branch or leader should be allowed still to maintain slightly its lead over the side branches. It should be noted here that the aim in the modified central-leader type is to develop a tree the top of which is composed of perhaps as many as 8 or 10 main limbs, instead of 3 to 5, as in the open-center tree, the limbs well placed along the central trunk with several inches of space between them, but ultimately, by cutting out the central leader, to avoid the more or less indefinite upward extension of the top. The main difference between the central-leader type of tree and the modified type is in the fact that by giving the central branch in the latter only a slight lead over the side branches, the upward extension of the top is less rapid than in the former type.

If a tree is planted as a 1-year-old and consists merely of a straight stem at that time, the side limbs which will usually develop during the season will be simply unbranched whips. Such a tree will be pruned very much as described for a 2-year-old tree at the time of planting.

Any shoots or suckers that may start from about the base of the tree or from the trunk below the limbs originally selected for the scaffold of the top should be removed.

It will thus be seen that the first dormant pruning following the planting is very definitely a formative process and is done with a view to developing a strong, stocky, well-balanced tree, the branches of which shall be so placed and so formed that they will possess the greatest possible strength in after years when the tree reaches the period of heavy crop production. It should be pointed out, however, that trees of different varieties may differ widely in their habits of growth. The natural tendencies should not be ignored, since the same pruning will not accomplish the same end in all cases.

Attention should here be directed to the fact that there is developing a rather strong tendency to prune young apple trees less heavily than has been the practice heretofore. This is due in part to a better understanding of the effects of pruning on the life processes of the tree. Young trees very heavily pruned are often, if not as a rule, less vigorous and make less growth the year following the pruning, both in extent of limbs and in diameter of trunk, than trees treated otherwise the same except that they are pruned but little. However, the results from cutting back limbs rather heavily,

so far as it keeps the top reasonably compact, prevents the limbs from becoming "leggy," and regulates the formation of side or secondary branches, are important in after years when the tree reaches full-bearing age. The importance, however, varies considerably with the habit and vigor of growth of the tree. It is much greater in the case of a variety that naturally makes a "leggy" unbranched growth than with one that makes a compact growth.

FIG. 32.—An apple tree planted as a 2-year-old now in its second season's growth in the orchard. The branches were cut back during the preceding dormant period; that is, following the first season's growth in the orchard. The development of from one to several side branches is here seen. Compare this with the tree shown in Figure 27, the branches of which were not cut back following the first season's growth. The tree is faulty in that the scaffold branches are too close together up and down the trunk.

THE SECOND YEAR'S PRUNING.

Pruning following the second season's growth after planting does not differ materially from that following the first season. Each of the branches left at the previous year's pruning will normally develop from one to several side branches, and since the tree will usually have become well established during the preceding season, the chances are that the growth the second season may be more vigorous than during the first one. These conditions are shown in Figure 32. During the first few years after a tree becomes well established a growth of the main branches of 18 inches to 3 feet, or sometimes more, may occur annually. From one-third to two-thirds of the length of the growth of the previous summer will likely need to be cut off for the purpose of keeping the top within bounds and to develop the strong stocky frame, which to a large extent is the object of the pruning at this time. However, where the growth is not over 18 or 20 inches, a slight cutting back is usually sufficient.

Moreover, the somewhat numerous secondary branches that usually develop at the beginning of the second season's growth from the limbs comprising the tree top will be likely to make the top rather dense. Some of these branches will need to be cut off entirely when pruned following the second season's growth. The ideal number to leave on each limb is two, thus when the pruning is completed doubling the number of branches that remained the year before when the seasonal pruning was completed. However, in the irregularities of growth it will be impracticable to thin the branches of the previous season's growth according to any arbitrary numerical standard. The removal should be with a view to keeping the top open, symmetrical, and well balanced. In some cases, perhaps, all the side branches of the previous season's growth will need to be removed, while in others more than two should be left to gain the ends mentioned above.

Where the central-leader or modified central-leader type of tree is being developed, the same general plan is followed at this time as in the preceding year.

THE THIRD YEAR'S PRUNING.

In pruning following the third season's growth the development of a strong, stocky, well-balanced open top should still be the aim.

The directions for the second year's pruning apply in substance to the third year. However, the number of branches has increased materially by this time compared with the first or second year, and as a result the length of the seasonal growth on individual limbs may be considerably less than in previous years, even though the total length of the annual growth may be greater. When these conditions prevail, pruning following the third season's growth may be limited largely to corrective work and consist mainly of cutting out crossing or other interfering branches and those that make the top too dense and heading back but little more than is necessary to keep the top symmetrical and well balanced.

Possibly by the third pruning a modified central-leader tree will have developed enough main limbs so that the central one can be removed at this time. If not, it should be continued for another year. A modified central-leader tree during its third season's growth is shown in Figure 33. While this tree is faulty in the spacing of the limbs on the trunk, it suggests the general plan by which a modified central-leader tree is developed.

Because of the fact previously touched on that heavy pruning of young trees tends to restrict the growth not only of the top but of the trunk and root system and delays bearing, the transition in the manner of pruning from that which has for its object the development of a compact well-branched top to that which anticipates fruitfulness should come as early in the life of the tree as practicable. This is influenced somewhat by the variety, habits of growth, and conditions under which the tree is grown.

PRUNING FROM THE FOURTH YEAR TO BEARING AGE.

Pruning the first three years is directed, except as noted in the preceding paragraph, toward the development of a strong, compact, stocky tree. In general, after the third season's growth, if the tree has been well handled, the foundation for future usefulness has been made, and it is then time to direct the pruning as definitely as possible toward future fruit production. In case of some varieties and under some conditions this stage may be reached a year earlier, as stated above. The heavy cutting back that has been done at the preceding annual prunings has tended to multiply the number of branches that make up the top. If this heavy pruning is continued the same results will follow, and these in their general effect are likely to be opposed to fruit production. Besides, in cutting back the annual growth heavily each year as the tree approaches normal bearing age, numerous buds are removed which in many cases would be the first to develop into fruit buds or fruit spurs. In this particular, however, varieties differ in their bearing habits. Some produce practically all their fruit on short spurs, while with others many terminal buds develop into fruit buds; they are also formed in the axils of the

leaves on the 1-year-old growth. It is such varieties that are likely to give the most striking results in fruit production with respect to whether or not they are headed back.

FIG. 33.—A Delicious apple tree in August of its third season's growth in the orchard, shaped according to the modified central-leader system of development.

Therefore, as a rule, pruning during the period in the life of the tree from the age of 3 or 4 years until bearing begins should be done conservatively. Thinning out the branches, if the top becomes too dense, will often be advisable, rather than heading back.

PRUNING BEARING TREES.

During the period from planting to bearing age pruning has consisted substantially of cutting back certain branches and thinning out the top by the entire removal of others. No new principle is involved in pruning bearing or mature trees. It still consists of the removal of some branches and the cutting back of others. During the first period the pruner thinks principally of the growth of the tree in relation to its vigor, strength of limb, symmetry of development, and compactness of the framework. Now, he thinks of the growth principally as it relates to the development of fruit buds and the subsequent development of the fruit.

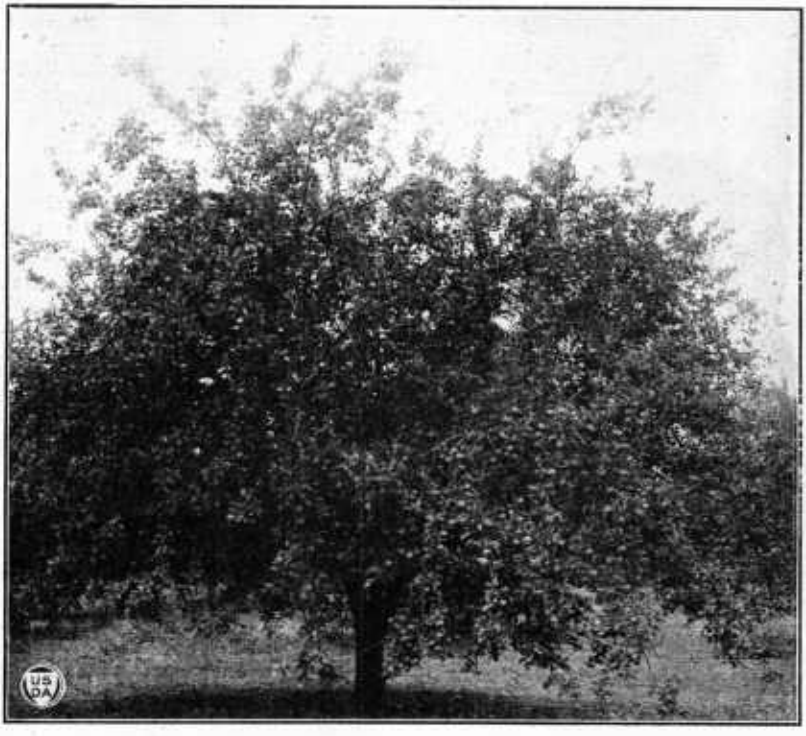


FIG. 34.—A well-formed, well-pruned Summer Hagloe apple tree about 30 years old. A tree having an open top, such as this, will develop fruit spurs throughout the top, and the fruit will receive sunshine enough to develop its color. Such a tree can be sprayed thoroughly, and the fruit can be picked with reasonable comfort to the picker.

The pruner should keep constantly in mind the fact that neither fruit spurs, fruit buds, nor the fruit itself develop well in dense shade. Therefore, in pruning a bearing tree the top should be kept sufficiently open to admit sunlight to the bearing areas. If kept well thinned out fruit spurs and buds can develop throughout the top, thus distributing the weight of the crop where it can be borne with the least danger of the branches breaking down. Where the top is so dense that the fruit buds develop only near the extremities of the limbs, even a light crop of fruit may result in serious breaking of the branches unless they are propped.

The intensity of the sunlight in different regions has some bearing on the degree of openness of the top. Where the sun's rays are very intense more attention than elsewhere must be given to keeping the larger limbs constantly shaded during the growing season to prevent sun scald on the upper or exposed side. Greater emphasis has doubtless been placed at times on this point than is warranted. However, when an attempt is made to put into proper condition a tree that has been allowed to become excessively dense, the shading of large limbs through the leaving of secondary branches is unquestionably necessary. Again, thorough spraying and economical harvesting are greatly promoted by keeping the top well open. The grower needs a mental picture of the tree he wishes to produce. That picture will vary for different varieties. Figure 34 shows a tree with a desirable open top.

As a routine matter all dead limbs should be removed at the annual pruning. But dead limbs will rarely be found in a tree that is well maintained, unless they are the result of some disease.

FIG. 35.—A stub left in removing a limb. It will never heal over. Decay will soon set in, and a rotten-hearted limb will be the inevitable result.

In order to keep the tree continuously in a fruit-producing condition a reasonable quantity of new growth must be made annually. As a rule a growth of 6 to 10 inches for the principal terminals is sufficient for a tree in full bearing. The extent of pruning that is wise as a means of stimulating this growth will vary from year to year as the condition of the tree varies.

SUMMER PRUNING.

Summer pruning has been much in the mind of fruit growers in recent years as a means of inducing greater fruitfulness, such pruning usually consisting in cutting back the terminal branches more or less. As a matter of fact, however, summer pruning not only fails frequently to increase fruit production but it may decrease it. The results, in other words, are often conflicting. Apparently there is some difference in the results in different regions, depending on the manner in which the different conditions affect the growth of the trees. There are also differences in results as between young trees growing rapidly and older ones that are fruiting. Summer pruning that reduces the leaf surface beyond a certain limit means a restricted growth of the tree, the growth being dependent upon the leaves to elaborate plant-food material. Different conditions of growth and food supply, however, may affect the results; also the time in the summer when the pruning is done.

In the case of bearing trees, if the leaf area is unduly reduced in summer pruning, not enough plant food is elaborated to nourish the tree and develop fruit buds. As a result, bearing trees which are pruned too heavily in summer may not produce as much fruit as trees not pruned in summer.

On the other hand, the checking of excessively strong growth at the right time by a limited amount of summer pruning may result in the formation of a larger number of fruit buds than would otherwise occur. This is when the pruning does not reduce the leaf surface beyond a point where the elaboration of plant food, which goes on only in the leaves, is adequate. Because of these uncertainties the grower should usually resort to summer pruning with considerable caution until he determines what its effects are likely to be under his particular conditions.

FIG. 36.—A wound properly made in cutting off a branch. No stub was left and healing will progress rapidly.

POSITION OF WOUNDS MADE IN PRUNING.

Much pruning is disastrous to the vitality of the tree because of improperly made wounds. In cutting off a limb it should be so done as not to leave a stub. A stub heals over slowly or not at all if it is of considerable length. In the latter case it soon becomes dead tissue and in due course decay develops and, extending into the main trunk or limb, results in a hollow rotten-hearted area. The beginning of such a condition is shown in Figure 35. In cutting off a branch the cut should be made parallel to the supporting limb, or very nearly so, and about as close to the limb as possible, even if by so doing the cut surface is somewhat larger than it would be if it were directly crosswise of the branch itself. A cut properly made in removing a limb is shown in Figure 36.

FIG. 37.—A wound resulting from cutting off a branch at an angle, leaving a stub on one side. No healing can take place on that side, but it is progressing well on the side where no stub remained.

The same care should be exercised in cutting off the small branches and even water sprouts, in order that the healing of the wounds may be hindered as little as possible. Even a short stub, such as the one shown in Figure 37. is objectionable.

TREATMENT OF WOUNDS MADE IN PRUNING.

In the case of properly made wounds of such size that they will heal over in one or two seasons, little, if anything, is likely to be gained by treating them in any way. If treatment of the larger wounds serves any useful purpose it will be in preventing the action of agencies, such as organisms of decay, that might gain entrance and retard the normal rate of healing. It may also prevent the cracking of the exposed wood tissue due to drying.

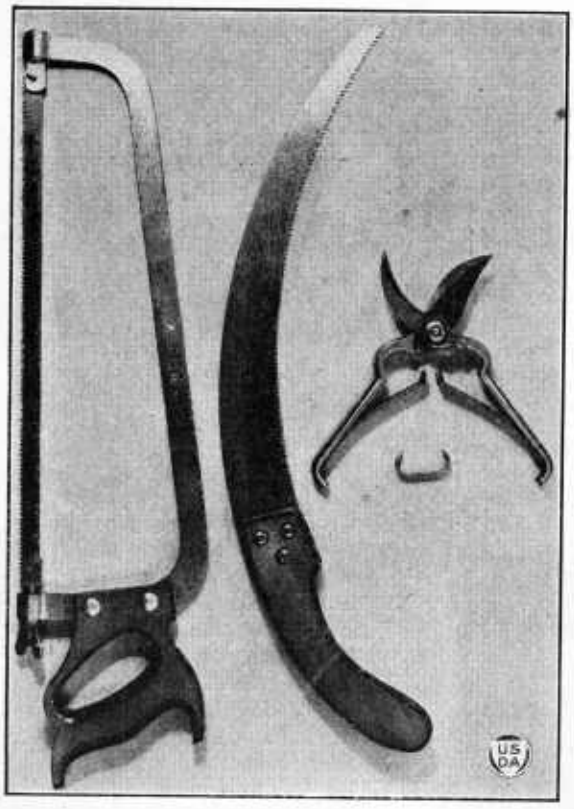


FIG. 38.—Pruning tools: A desirable type of hand pruning shears, a curved saw which cuts on the "pull" stroke, and a saw of the meat-saw type.

As a covering material, white lead cut with pure linseed oil and thinned to the consistency of a thick paint is perhaps more commonly used than anything else. Among several things, including white-lead paint, tried by the Missouri Agricultural Experiment Station, grafting wax [5] was one of the most satisfactory materials. In using the wax it was melted slightly and applied with a paint brush.

A coal-tar creosote preparation consisting of two-thirds to three-fourths ordinary coal tar and one-third to one-fourth creosote, or enough of the later so that when mixed with the coal tar it can be applied easily with a brush, is sometimes recommended. Care must be exercised in heating the coal tar to mix with the creosote not to bring it in contact with a flame, as it takes fire readily.

[5] This was composed of the following materials used in the proportions indicated: Rosin, 4 pounds; beeswax, 2 pounds; raw linseed oil, 1 pint.

In case of very large wounds the protective covering, whatever it is, will usually need to be reapplied every season or two to serve its intended purpose fully.

PRUNING TOOLS.

In pruning small trees a strong pruning knife and a pair of hand-pruning shears, as a rule, are all that should be necessary. Later on, as the trees develop, a pruning saw will be required. There are various types of saws. Personal preference is a strong factor in selection. One with a narrow straight blade is usually satisfactory, while some find a curved saw which cuts on the pull instead of on the push stroke a very desirable type. To one accustomed to it, the "meat-saw" type is usually a favorite. The blade of this type is very narrow and swiveled in the frame so that it can be set at any angle.

Heavy lopping shears with handles 2 or 2½ feet long are sometimes useful, but they are likely to crush and bruise the limbs more or less in cutting with them, and it is difficult to avoid making stubs. Figure 38 shows various kinds of pruning tools.

SPRAYING.

Spraying is here referred to only for the purpose of indicating its rightful place in orchard management. Information regarding the control of the principal apple insects and diseases is given in other bulletins.[6]

Spraying is one of the four basic operations in orchard management, the four being tillage (or some other method of soil management), fertilizing, pruning, and spraying. Not infrequently all the other operations are well executed but the fruit is inferior because of faulty spraying. Either the spray mixtures are not thoroughly applied, or they are not put on at the proper time, or the right preparation is not used. Such insects as the roundheaded apple-tree borer and diseases of which pear-blight is an example can not be controlled by spraying. To the extent that insects and diseases are the limiting factors, spraying and other measures are essential. Without their use successful commercial apple production is impossible.

PROTECTING THE TREES AGAINST RABBITS AND MICE.

As many apple growers know by experience, rabbits and mice frequently do great damage to young apple trees by gnawing the bark from the trunks, in many instances completely girdling them. Mice may burrow in the soil and girdle the tree just below the surface of the ground, or they may even work on the larger roots near the base

[6] For information regarding the control of apple diseases and insects the reader is referred to the following Farmers' Bulletins, which may be obtained free from the United States Department of Agriculture: The apple-tree tent caterpillar; No. 662. The roundheaded apple-tree borer; No. 675. The leaf blister mite of pear and apple; No. 722. The oyster-shell scale and the scurfy scale; No. 723. Orchard barkbeetles and pinhole borers and how to control them; No. 763. Information for fruit growers about insecticides, spraying apparatus, and important insect pests; No. 908. Apple bitter-rot and its control; No. 938. The flat-headed apple-tree borer; No. 1065. Control of apple powdery mildew; No. 1120. Control of aphids injurious to orchard fruits, currant, gooseberry, and grape; No. 1128. The more important apple insects; No. 1270.

of the tree. Where the injury is on the underground parts, it is likely to pass unnoticed until the tree shows signs of distress some time during the growing season as a result of the girdling or other serious injury that has occurred. It is then usually too late to apply an effective remedy.

In any event, prevention is much better than the necessity of resorting to remedies, and by anticipating trouble from rabbits and mice, which is likely to occur any winter and in almost any region, effective and relatively inexpensive means of protection can be adopted. The cost of applying them is offset by the saving of even a relatively few trees or even in avoiding the use of such remedial measures as can be resorted to after injury has occurred.

Preventive and remedial measures are described in various Farmers' Bulletins with which the grower should provide himself.[7]

THINNING THE FRUIT.

Under favorable conditions apple trees often set a much larger crop of fruit than can be developed and matured to that degree of size and perfection essential to the fruit-grower's purpose. The development of the seeds is far more depleting to the vitality of the tree than the development of the pulp. Hence, the production of seeds beyond certain limits is opposed to the production of fruit of large size and fine appearance.

Thinning may also be done to prevent the breaking of the limbs by the weight of an excessive burden of fruit. Since the larvæ of the codling moth are likely to work seriously on fruits in contact with one another, as when in clusters, it is well as a rule to reduce clusters of fruit to a single specimen. Then, too, in the case of some varieties with very short stems, thinning is desirable as a means of preventing fruits in clusters from being forced off by the pressure of one fruit against another as they increase in size.

The thinning should be done, at least on late varieties, just after the "June drop," which occurs a month or six weeks after blossoming, when the imperfectly fertilized and other weak fruits drop. This does not necessarily occur during June, since it may take place before or later, depending on the region and the time of blossoming.

Thinning is essentially handwork, since no other satisfactory means of removing the fruits have been devised. Some use small shears made for the purpose, to clip the stems; others prefer to use the hands direct.

The cost of thinning is dependent mostly on the time required to do the work, but other factors are involved. In going over the trees the wormy and otherwise imperfect fruits are removed. While many of these would probably drop before harvest, much of the fruit that is removed in thinning would otherwise remain until the crop is harvested. At harvest time the imperfect fruit and that of low grade (in case of no thinning) must be picked and handled with the better grades and much of it probably discarded as cull fruit. Obviously, it would be cheaper to pick such fruit in June and drop it on the ground than to delay until fall, then pick it, and

[7] Bridge grafting; No. 1369. Cottontail rabbits in relation to trees and farm crops; No. 702. Mouse control in field and orchard; No. 1397.

carry it to the packing table, where it must be handled over again in grading and packing operations. Both the experience of careful growers and experimental evidence have demonstrated that the gains in size, color, and market value on the one hand and the lessened requirement of work at harvest time often represent savings in cost which largely offset the expense of thinning.

A FINAL WORD.

The efficient apple grower studies his enterprise from every angle. There is little in orchard management that can be done successfully by rule. A given practice or method may give very different results when followed under varying conditions. If the grower knows the underlying principles that are involved, he modifies the details of practice to meet the requirements of changing conditions.

Again, a grower needs to know whether his methods are yielding returns proportionate to the costs. If he is using fertilizers, he must know whether he is receiving therefrom sufficiently increased returns and other benefits to pay the costs of the material and labor involved. Other activities are equally important in this respect.

In order that the grower may have this needed information about his orchard affairs, he must be businesslike. He must study methods and their effects. He must keep accounts relating to costs of material and labor and other expenditures; otherwise he can not determine what activity represents profit and what represents loss. The Babcock milk test makes possible the elimination of the cow that does not yield a profitable return on the cost of keeping her. The apple grower needs to apply this idea to his orchard operations. He needs so to manage his orchard that he will secure the largest and most regular crops of high-grade fruit at the smallest relative cost of production. The main problem with the average apple grower is to make his orchard more profitable. The annual costs of maintenance, that is, of tillage, spraying, fertilizing, pruning, etc., and the overhead charges, such as taxes and interest on his investment, are more or less fixed, with only seasonal variations as influenced by conditions. It requires the proceeds from a certain quantity of fruit to meet these expenses of orchard maintenance. It is the profit-producing portion of the crop that is of chief concern to the grower; he should endeavor to increase this by every practicable means.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

March 5, 1924.

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